CELLA BARR ASSOCIATES

STORM DRAINAGE SYSTEM
FOR
MCDOWELL ROAD IMPROVEMENTS
64TH STREET TO INDIAN BEND WASH
SCOTTSDALE, ARIZONA
PART 1-HYDROLOGY & CONCEPT DESIGN REPORT
AUGUST 1985 (UPDATED MARCH 1986)
PROJECT NO. S 5504
CBA FILE NO. 40785-01-32
PWRH-85

REGISTERED PROFESSIONAL ENGINEER (CIVIL)
CERTIFICATE NO.
19268
THOMAS A.
WALKER
Date Signed 4-25-86
ARIZONA, U.S.A.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

TABLE OF CONTENTS (cont'd)

LIST OF FIGURES (cont'd)

TABLE OF CONTENTS (cont'd)

APPENDICES

LIST OF MAPS

I. INTRODUCTION

The City of Scottsdale has contracted Cella Barr Associates (CBA) to provide engineering services for the design of a storm sewer system and road improvements on McDowell Road from 64th Street to Indian Bend Wash. This report is Part 1 of a two part study documenting the hydrology, conceptual design and hydraulic design computations used to develop the final storm drainage system.

The purpose of this drainage report is to identify and analyze the watershed and its respective drainage basins contributing surface water runoff to McDowell Road. After a thorough investigation, the expected runoff in cubic feet per second (cfs) for the 2, 10, 25 and 100 year return frequency storms were computed and are presented in this report.

The hydrologic information presented in this report was used to develop the conceptual storm drainage system, and establish parameters for the final storm drainage design. Changes have thus been made to this report, since its initial development, to reflect the refinements made during the design phase. Reference should also be made to Part 2-Hydraulic Design Report" for the final sizing of the storm drain system and the associated hydraulic computations.

II. PROJECT LOCATION

Improvements on McDowell Road in Scottsdale extend from 1,500 feet west of 64th Street to Indian Bend Wash, approximately 1.7 miles to the east. Also included as part of this project are road improvements at the intersections of each major cross street and on 64th Street for a distance of 1,100 feet both north and south of the McDowell Road intersection.

A distinct landmark in this area is the Cross Cut Canal which intersects McDowell Road between 64th and 68th Streets (Figure 1). The Cross Cut Canal effectively divides the area draining to McDowell Road into two distinct watersheds, both in terms of topography and land use. The area west of the canal is predominantly composed of undeveloped gently rolling land and extends west to the base of the rocky McDowell Buttes and north to Thomas Road (Figure 1). Property to the east of 64th Street is mostly improved residential or has potential for residential development.

East of the canal, the majority of the watershed contributes runoff from Palm Lane south to McDowell Road. In addition, localized contributions are made from commercial properties along the south side of McDowell Road. Most of the watershed contributing runoff to McDowell Road is classified as either residential or commercial property. Virtually all of the land adjacent to McDowell Road is zoned as commercial and is developed from the canal, east to Indian Bend Wash. Residential domiciles comprise the remainder of the watershed laying north and south of commercial parcels along McDowell Road.

These drainage areas generally have a 0.8% slope from west to east with a 0.2% slope from north to south. Natural drainage is towards Indian Bend Wash and as a result, a great deal of drainage is directed eastward along McDowell Road.

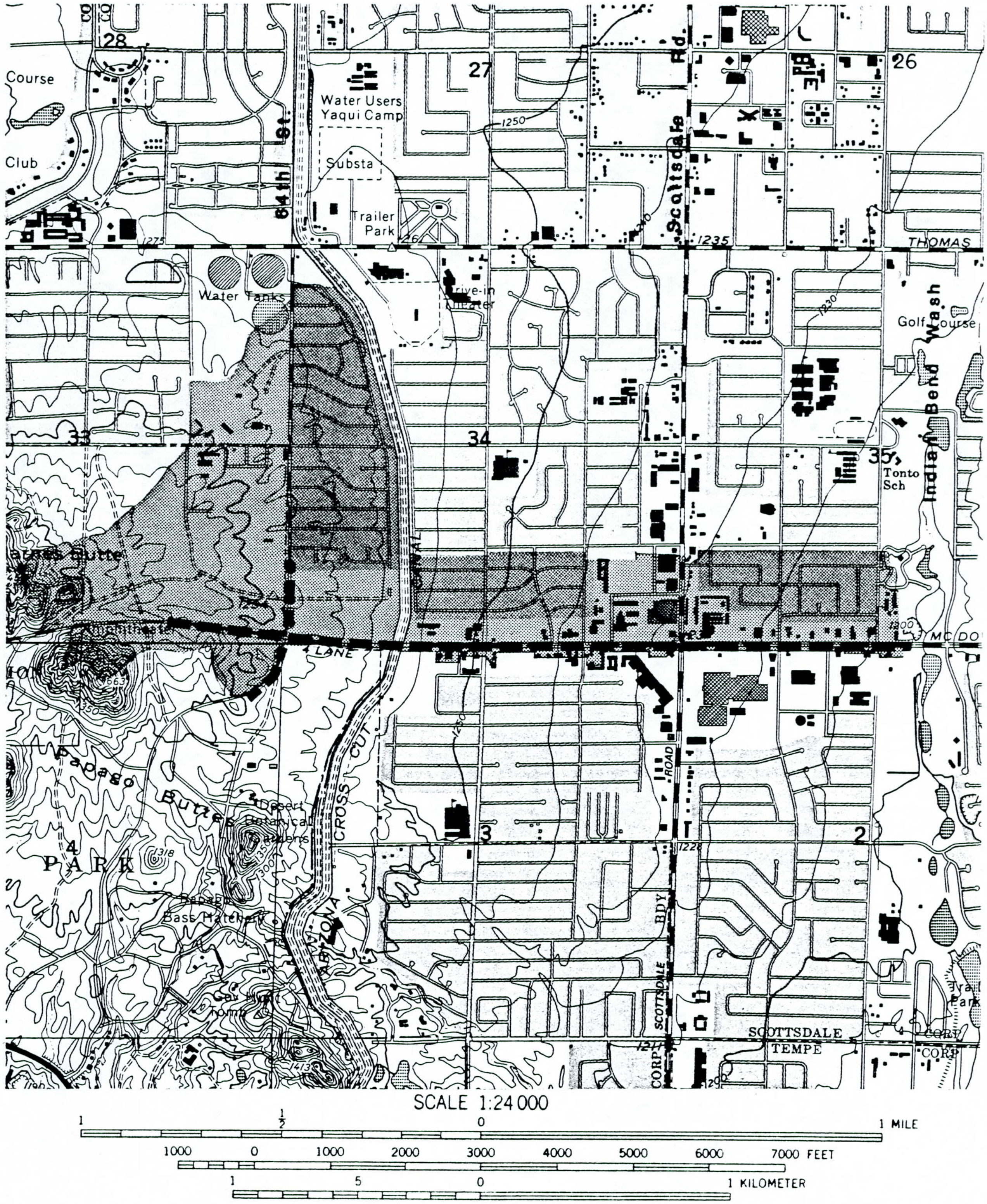


FIGURE 1:

McDOWELL ROAD PROJECT LOCATION MAP

EXPLANATION

GENERALIZED DRAINAGE AREA.

EXTENT OF ROAD IMPROVEMENTS.

CELLA BARR ASSOCIATES

III. EXISTING DRAINAGE CONDITIONS

Storm water runoff west of the Cross Cut Canal originates in the McDowell Buttes and concentrates into seven different drainage basins. These drainage areas contribute flows to McDowell Road and portions of 64th Street which are within this scope of work. Map 1 shows the location and designations of each of these contributing drainage areas. As shown on this map, six washes cross 64th Street within the limits of the project improvements. Refering to Map 1 (west of canal), drainage areas 1 and 2 extend north to Thomas Road, and contribute runoff towards the Cross Cut Canal. Ponding results behind the Canal because of berming above the natural ground elevation and the inability to quickly drain the area. A drainage channel west of the canal intercepts this runoff and conveys it southward toward McDowell Road. At McDowell Road, drainage crosses through a 48" CMP and a bicycle crossing which also acts as a culvert. Area 3 drainage crosses 64th Street through a dip section in the pavement into area 3A. The major portion of drainage area 4 lies north of McDowell Road and receives additional runoff from areas 4A, 4B, 4C, and 4D through four individual 24" culverts. These flows combine and continue east, crossing 64th Street through a single 36" CMP. After crossing 64th Street the runoff combines [redacted] areas 3 and 3A before crossing south under McDowell Road through a 4' x 6' box culvert. Area 5 currently crosses 64th Street through a dip section while area 6 is directed through a 24" RCP. Drainage from area 7 currently is conveyed north to an existing culvert and some sheet flow occurs across 64th Street.

Between the canal and Scottsdale Road the drainage area contributing to McDowell Road is bounded by Palm Lane to the north and McDowell Road to the south. The general topography in this area slopes from west to east and the east-west streets convey the predominant amount of storm water runoff. It should be noted that some of this runoff is intercepted by the north-south streets, 68th Street, 69th Street, 70th Street and Scottsdale Road, and is conveyed south to McDowell Road. Only in storms large enough to top the curbs will runoff flow through neighborhoods and follow its natural course.

A large commercial development is situated north of McDowell Road on Scottsdale Road. Initial runoff will be retained within the parking lot but subsequent, higher frequency storms will result in runoff to Scottsdale Road. Scottsdale Road has a natural low near its intersection with Palm Lane. Ponding occurs in this area and as a result, catch basins and a 36" storm drain system have already been constructed to convey storm water south to the McDowell Road intersection. Scottsdale Road has a large capacity to convey storm water south before the curb and median is topped and as a result, the runoff from all frequency storms considered is conveyed to the intersection of Scottsdale Road and McDowell Road. Additional storm water is intercepted by catch basins at the intersection and conveyed south through an existing 60" storm drain. Excess runoff continues either east on McDowell Road or south on Scottsdale Road.

East of Scottsdale Road, Palm Lane again forms the northern drainage boundary and McDowell Road the south boundary. Runoff from local residences is intercepted by 74th Street and Miller Road and conveyed south to McDowell Road. Drainage exceeding the street capacity of 74th Street flows through neighborhoods to the east. All water reaching Miller Road is carried south toward McDowell Road because of berming around the park in Indian Bend Wash. Storm water is unable to flow south on Miller Road from the intersection with McDowell Road because of the steep road grade. For this reason, water is concentrated at a low point on McDowell Road just west of the Indian Bend Wash road bridge. Existing catch basins intercept this drainage and convey it directly to Indian Bend Wash through a 24" connector pipe.

IV. METHODOLOGY

As previously mentioned, the Cross Cut Canal effectively divides the drainage areas contributing surface water runoff to McDowell Road into two distinct east and west watersheds. For this reason, the east and west watersheds were independently evaluated for peak discharges during the 2, 10, 25, and 100 year precipitation events.

During the course of the drainage investigation it became apparent that the west and east watersheds differed significantly in their hydrologic characteristics and thus necessitated different methods of peak discharge evaluation. The analysis chosen to determine peak discharges for the 2, 10, 25, and 100 year return frequency storms were taken from the Arizona Department of Transportation (A.D.O.T.) Publication entitled: Hydrologic Design For Highway Drainage In Arizona (1968). West of the canal the Soil Conservation Service (SCS) method was utilized while east of the canal the Rational Method was employed. The components of both watersheds and an evaluation of the different methodologies are discussed in the following paragraphs.

Drainage area west of the Cross Cut Canal:

The watershed west of the Cross Cut Canal is composed of both open desert and urban reaches. This drainage area encompasses approximately 0.54 square miles and contains several sub-areas which contribute runoff to McDowell Road. The complete watershed and respective sub-areas are shown on Map 1. The SCS method of determining peak discharges for various magnitude storms was employed to analyze this watershed due to a combination of size and complexity of slopes found in this particular drainage area.

Each sub-basin of the watershed was defined by incorporating air photo derived from the combination of these sources made ithpoisfbleation determine elevations, distances, and land slopes in order to compute a reasonable estimate of time of concentration for each individual sub-area.

The time of concentration (T_c) is defined as the period of time required for storm water runoff to travel from the most distant point on the watershed to the point of concentration where the peak flow is estimated. Since the T_c is not additive from sub-area to sub-area, the T_c must be calculated for each particular drainage area. These calculations are shown in Appendix 1. In some instances such as drainage Areas 1 + 2, the T_c was based upon overland and gutter flows. In other cases (3 + 3A, 4 + 4A-D, 3 + 3A + 4A-D) T_c values were computed based upon the longest travel time of several hydrologically connected drainage areas.

Another component of the SCS method is the runoff curve number. This is a measure of the runoff that results from a given rainfall amount and is based upon the combined effect of antecedent moisture conditions, soil, vegetative type, density cover, and man-made features.

The curve number for drainage area 1 + 2 was determined from the weighted average of developed and undeveloped land. The curve number for the remaining drainage areas was determined based upon the soil type (Type D) and the vegetative type and cover (Desert Brush, 15% cover).

Tables 1 through 4 summarize the drainage area parameters for the watershed west of the Cross Cut Canal. Each table displays composite summarizations for the 2, 10, 25, and 100 year return frequency storms. Map 1 shows the watershed and drainage area designations in addition to generalized flow directions of surface water runoff.

Drainage Area East of the Cross Cut Canal:

The watershed east of the Cross Cut Canal is predominantly developed land consisting of residential and commercial properties. Six main drainage areas have been identified in this watershed which contribute surface water runoff to McDowell Road. These six drainage areas have been further divided into sub-areas as shown on Map 1. Peak discharges for the 2, 10, 25 and 100 year frequency storms were determined by applying the Rational Method of analysis. This method is more suitable for this area because of the extent of urbanization and the reduced size of the individual sub-areas.

The drainage areas and their respective sub-areas of this watershed were delineated from air photo topography, aerial photographs, USGS topographic map, and field reconnaissance. Slopes and distances were primarily derived from field measurements referenced to existing monumentation. Figure 2 illustrates the six major drainage areas and their individual sub-areas in addition to acting as a key map for Figures 3 and 4.

Sub-areas were differentiated according to north-south streets extending through or to McDowell Road. Figure 2 shows these roads and resultant sub-area designations. The purpose of these designations is to consider each street as an effective diversion point capable of conveying a limited amount of surface water runoff. For this reason cross sections were prepared from a combination of air photo topography and field survey notes and individual street capacities calculated.

Street capacities north of McDowell Road were calculated assuming that full capacity is reached when flows top the crown of the street by 0.1 foot. Once the street capacity is reached all other runoff will sheet flow to the east.

Street capacities south of McDowell Road were computed at three different levels which include: 1.) total capacity, 2.) 100 year criteria and, 3.) 2 year criteria (criteria taken from the City of Scottsdale drainage manual, Section 3-501, "Design Procedures and Criteria - Design of Facilities to Manage Stormwater Runoff"). Table 5 lists each street and shows its corresponding capacity.

TABLE 1: DRAINAGE AREA DISCHARGES WEST OF CANAL. SCS METHOD

STORM FREQUENCY = 2 Year
P_1 = 0.93

DRAINAGE AREA	AREA	CN	Q	T_c	Wf	T_p	Q_p
1 + 2	0.398	88	0.25	1.54	0.89	1.37	35
2	0.012	92	0.35	0.17	1.24	0.21	10
3	0.048	92	0.35	0.28	1.24	0.35	23
3 + 3A	0.054	92	0.35	0.32	1.24	0.40	23
4	0.029	92	0.35	0.28	1.24	0.35	14
4A	0.0078	92	0.35	0.28*	1.24	0.35	4
4B	0.0019	92	0.35	0.28*	1.24	0.35	1
4C	0.0119	92	0.35	0.28*	1.24	0.35	6
4D	0.0058	92	0.35	0.28*	1.24	0.35	3
4+4A+4B+4C+4D	0.056	92	0.35	0.28*	1.24	0.35	27
3+3A+4,A,B,C,D	0.11	92	0.35	0.32**	1.24	0.40	47
5	0.0062	92	0.35	0.17	1.24	0.21	5
6	0.0062	92	0.35	0.17	1.24	0.21	5
7	0.0111	92	0.35	0.17	1.24	0.21	9

Area = Square Miles
CN = Curve Number
Q = Runoff-inches
T_c = Time of Concentration - Hours
W_f = Width Factor
T_p = Time of Peak $(T_c)(W_f)$ - Hours
Q_p = Peak Discharge - Cubic Feet per Second

$$Q_p = \frac{484\ AQ}{T_p}$$

* Based upon a T_c value calculated from drainage Area 4.
** Based upon a T_c value calculated from drainage Area 4 + 3A.

TABLE 2: DRAINAGE AREA DISCHARGES WEST OF CANAL. SCS METHOD

STORM FREQUENCY = 10 Year
P_1 = 1.56

DRAINAGE AREA	AREA	CN	Q	T_c	W_f	T_p	Q_p
1 + 2	0.398	88	0.65	1.54	0.89	1.37	91
2	0.012	92	0.85	0.17	1.24	0.21	23
3	0.048	92	0.85	0.28	1.24	0.35	56
3 + 3A	0.054	92	0.85	0.32	1.24	0.40	55
4	0.029	92	0.85	0.28	1.24	0.35	34
4A	0.0078	92	0.85	0.28*	1.24	0.35	9
4B	0.0019	92	0.85	0.28*	1.24	0.35	2
4C	0.0119	92	0.85	0.28*	1.24	0.35	14
4D	0.0058	92	0.85	0.28*	1.24	0.35	7
4+4A+4B+4C+4D	0.056	92	0.85	0.28*	1.24	0.35	66
3+3A+4,A,B,C,D	0.11	92	0.85	0.32**	1.24	0.40	113
5	0.0062	92	0.85	0.17	1.24	0.21	12
6	0.0062	92	0.85	0.17	1.24	0.21	12
7	0.0111	92	0.85	0.17	1.24	0.21	22

Area = Square Miles
CN = Curve Number
Q = Runoff-inches
T_c = Time of Concentration - Hours
W_f = Width Factor
T_p = Time of Peak $(T_c)(W_f)$ - Hours
Q = Peak Discharge - Cubic Feet per Second

$$Q_p = \frac{484\ AQ}{T_p}$$

* Based upon a T_c value calculated from drainage Area 4.
** Based upon a T_c value calculated from drainage Area 4 + 3A.

TABLE 3: DRAINAGE AREA DISCHARGES WEST OF CANAL. SCS METHOD

STORM FREQUENCY = 25 Year
P_1 = 1.98

DRAINAGE AREA	AREA	CN	Q	T_c	Wf	Tp	Qp
1 + 2	0.398	88	1.0	1.54	0.89	1.37	141
2	0.012	92	1.2	0.17	1.24	0.21	33
3	0.048	92	1.2	0.28	1.24	0.35	80
3 + 3A	0.054	92	1.2	0.32	1.24	0.40	78
4	0.029	92	1.2	0.28	1.24	0.35	48
4A	0.0078	92	1.2	0.28*	1.24	0.35	13
4B	0.0019	92	1.2	0.28*	1.24	0.35	3
4C	0.0119	92	1.2	0.28*	1.24	0.35	20
4D	0.0058	92	1.2	0.28*	1.24	0.35	10
4+4A+4B+4C+4D	0.056	92	1.2	0.28*	1.24	0.35	93
3+3A+4,A,B,C,D	0.11	92	1.2	0.32**	1.24	0.40	160
5	0.0062	92	1.2	0.17	1.24	0.21	17
6	0.0062	92	1.2	0.17	1.24	0.21	17
7	0.0111	92	1.2	0.17	1.24	0.21	31

Area = Square Miles
CN = Curve Number
Q = Runoff-inches
T_c = Time of Concentration - Hours
W_f = Width Factor
T_p = Time of Peak $(T_c)(W_f)$ - Hours
Q_p = Peak Discharge - Cubic Feet per Second

$$Q_p = \frac{484\ AQ}{T_p}$$

* Based upon a T_c value calculated from drainage Area 4.
** Based upon a T_c value calculated from drainage Area 4 + 3A.

TABLE 4: DRAINAGE AREA DISCHARGES WEST OF CANAL. SCS METHOD

STORM FREQUENCY = 100 Year
P_1 = 2.63

DRAINAGE AREA	AREA	CN	Q	T_c	W_f	T_p	Q_p
1 + 2	0.398	88	1.55	1.54	0.89	1.37	218
2	0.012	92	1.75	0.17	1.24	0.21	48
3	0.048	92	1.75	0.28	1.24	0.35	116
3 + 3A	0.054	92	1.75	0.32	1.24	0.40	114
4	0.029	92	1.75	0.28	1.24	0.35	70
4A	0.0078	92	1.75	0.28*	1.24	0.35	19
4B	0.0019	92	1.75	0.28*	1.24	0.35	5
4C	0.0119	92	1.75	0.28*	1.24	0.35	29
4D	0.0058	92	1.75	0.28*	1.24	0.35	14
4+4A+4B+4C+4D	0.056	92	1.75	0.28*	1.24	0.35	135
3+3A+4,A,B,C,D	0.11	92	1.75	0.32**	1.24	0.40	233
5	0.0062	92	1.75	0.17	1.24	0.21	25
6	0.0062	92	1.75	0.17	1.24	0.21	25
7	0.0111	92	1.75	0.17	1.24	0.21	45

Area = Square Miles
CN = Curve Number
Q = Runoff-inches
T_c = Time of Concentration - Hours
W_f = Width Factor
T_p = Time of Peak $(T_c)(W_f)$ - Hours
Q = Peak Discharge - Cubic Feet per Second

$$Q_p = \frac{484\ AQ}{T_p}$$

* Based upon a T_c value calculated from drainage Area 4.
** Based upon a T_c value calculated from drainage Area 4 + 3A.

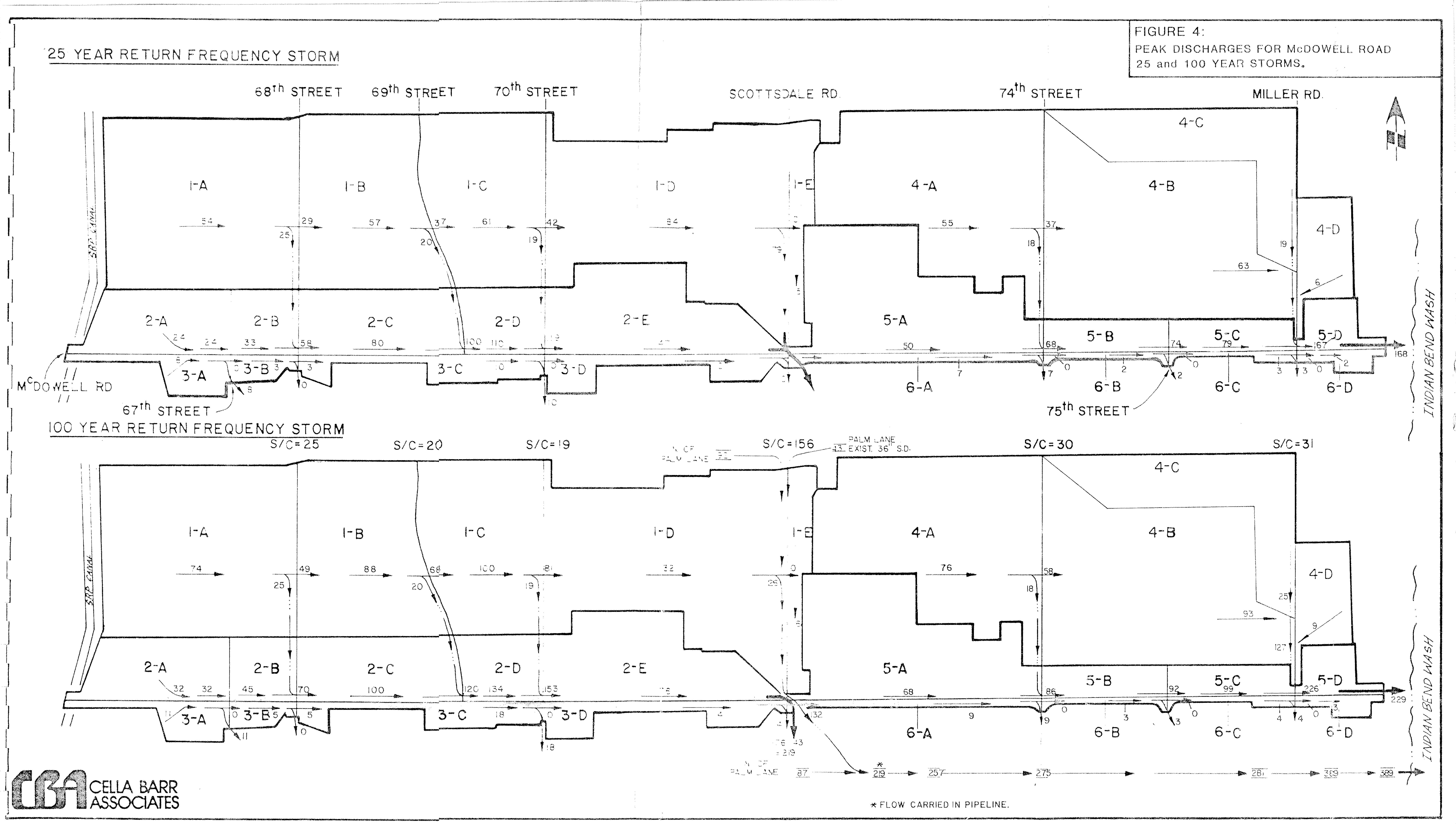


FIGURE 4:
PEAK DISCHARGES FOR McDOWELL ROAD
25 and 100 YEAR STORMS.

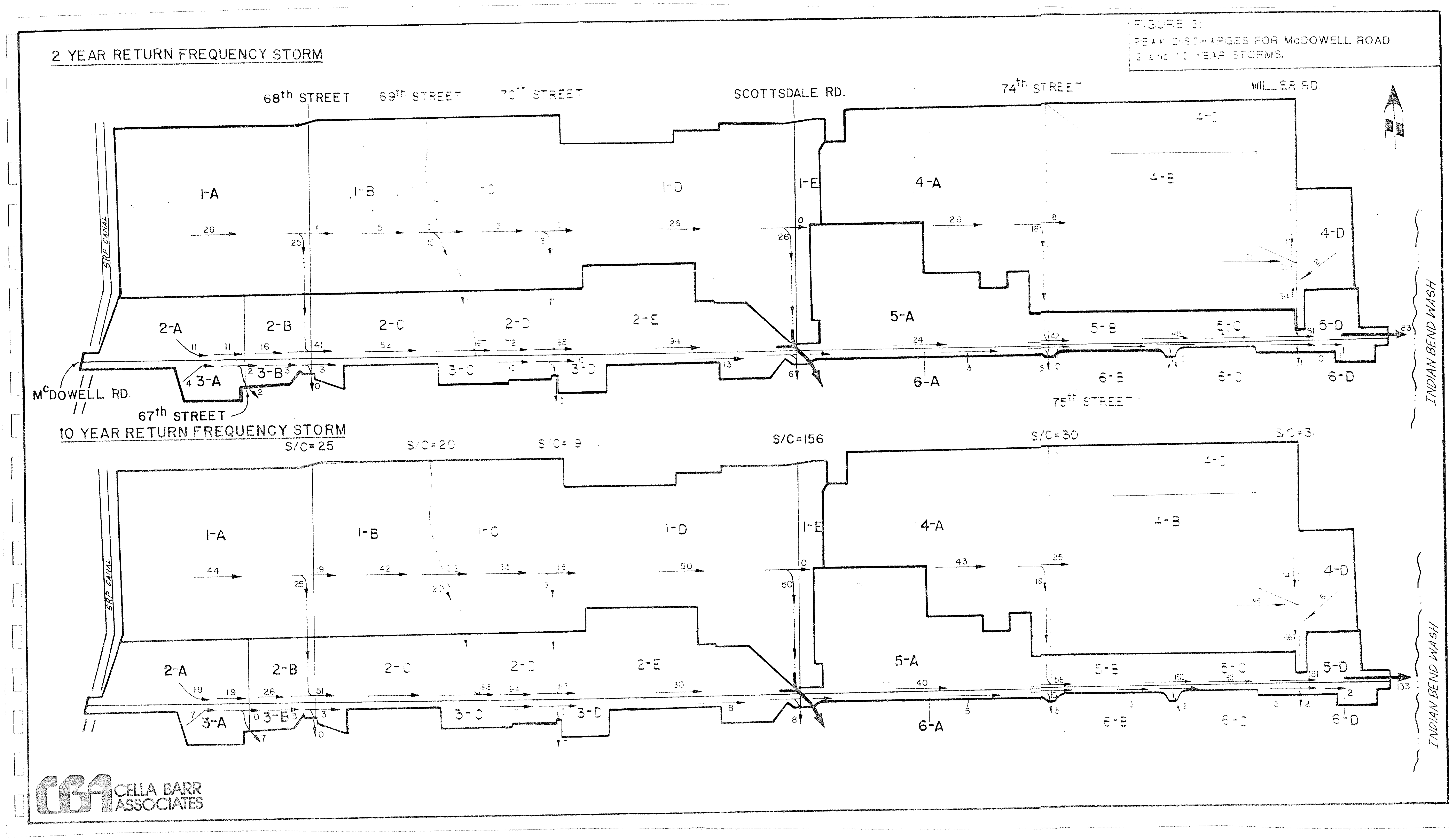


FIGURE 3. PEAK DISCHARGES FOR McDOWELL ROAD 2 and 10 YEAR STORMS.

TABLE 5: Street Capacities, McDowell Road Storm Drain.

North of McDowell Road:

Street	Slope (ft/ft)	Street Capacity (cfs)1
68th	0.0026	25
69th	0.003	18
70th	0.0018	19
Scottsdale Rd.	0.002	156
74th	0.0013	18
Miller Rd.	0.0024	31

South of McDowell Road:

Street	Slope	Street Capacity	100-yr (cfs)2	2-yr (cfs)2
67th	0.013	78	78	2
68th	0.004	25	0	0
70th	0.0039	30	30	0
Scottsdale Rd.	0.0043	56	43	0
74th	0.0072	10	10	5
75th	0.01	39	39	0
Miller Rd.	0.004	22	10	4

NOTE:

1. Street capacities are based upon the total volume of water that will be conveyed by the street allowing for a 0.1 foot surcharge above the crown or top of curb. Flows in excess of those shown will continue across the street in a west-east direction following their natural flow patterns.

2. The City of Scottsdale design criteria, as defined in Section V, allows for a maximum flow depth and street flooding width for the 100-year and 2-year frequency storms. Discharge values shown are the maximum allowable under these cirteria.

The cross sections of each street and capacity calculations are displayed in Appendix 2.

An essential element in evaluating peak discharges by the Rational Method is the time of concentration (Tc). Calculating a Tc for this watershed posed a variety of problems. Paramount among these are the size and complexity of the watershed and cumulative effects of surface water runoff.

In order to compute Tc values, each individual sub-area was analyzed. This involved calculating the drainage area and travel distances, and determining the average slope. The east-west (E-W) slope was computed from the average slope of McDowell Road measured 120 feet east of the canal to 360 feet west of Miller Road. North-south (N-S) slopes were calculated from adjoining N-S streets. After the slopes were determined, Tc values were calculated from the velocity formula which takes the form:

$$V = 54(S)^{1/2}$$

A minimum time of 10 minutes was included in the Tc value to account for the watershed's initial precipitation interaction. Since the Tc value for a particular drainage area is not additive to its sub-areas, a cumulative Tc needed to be determined for each individual sub-area. This was accomplished by progressively evaluating one sub-area and its total distance then adding it to the next until the end of the drainage area is met. Tc calculations are shown in Appendix III.

Runoff coefficients were estimated based upon the percentage of roof, asphalt and ground coverage. Depending on the drainage area, in some cases a weighted average was used. These calculations are shown in Appendix IV.

Tables 6 through 9 summarize the resulting data for each sub-area in terms of acreage, runoff coefficient, Tc, rainfall intensity and peak discharges. Figures 3 and 4 exhibit the cumulative peak discharges, and flow directions of various return frequency storms.

TABLE 6: DRAINAGE AREA DISCHARGES EAST OF CANAL

STORM FREQUENCY = 2 year
P_1 = 0.93

DRAINAGE AREA 1

SUB-AREA	ACRES	RUN. COEF.	T_c	I (In/Hr.)	Q (cfs)
A	20.8	0.54	13	2.3	26
A+B	35.4	0.54	16	2.1	40
A+B+C	47.9	0.54	18	2.0	52
A+B+C+D	72.3	0.64	30	1.5	69
A+B+C+D+E	74.6	0.64	30	1.5	72

DRAINAGE AREA 2

A	5.8	0.85	13	2.3	11
A+B	8.4	0.85	14	2.2	16
A+B+C	15.4	0.85	17	2.1	27
A+B+C+D	18.7	0.85	18	2.0	32
A+B+C+D+E	28.6	0.85	25	1.7	41

DRAINAGE AREA 3

A	2.0	0.85	13	2.3	4
B	0.9	0.85	13	2.3	2
C	2.9	0.85	13	2.3	6
D	1.8	0.85	13	2.3	4

DRAINAGE AREA 4

A	21.1	0.57	14	2.2	26
A+B	44.0	0.56	26	1.6	39
A+B+C	53.9	0.56	26	1.6	48
A+B+C+D	57.6	0.56	26	1.6	52

DRAINAGE AREA 5

A	14.7	0.85	19	1.9	24
A+B	17.4	0.85	21	1.8	27
A+B+C	19.9	0.85	23	1.7	29
A+B+C+D	21.8	0.84	25	1.7	31

DRAINAGE AREA 6

A	1.7	0.85	13	2.3	3
B	0.6	0.85	13	2.3	1
C	0.8	0.85	13	2.3	2
D	0.9	0.84	13	2.3	2

TABLE 7: DRAINAGE AREA DISCHARGES EAST OF CANAL

STORM FREQUENCY = 10 year
P_1 = 1.56

DRAINAGE AREA 1

SUB-AREA	ACRES	RUN. COEF.	T_c	I (In/Hr.)	Q (cfs)
A	20.8	0.54	13	3.9	44
A+B	35.4	0.54	16	3.5	67
A+B+C	47.9	0.54	18	3.1	80
A+B+C+D	72.3	0.64	30	2.4	111
A+B+C+D+E	74.6	0.64	30	2.4	114

DRAINAGE AREA 2

A	5.8	0.85	13	3.9	19
A+B	8.4	0.85	14	3.6	26
A+B+C	15.4	0.85	17	3.3	43
A+B+C+D	18.7	0.85	18	3.1	49
A+B+C+D+E	28.6	0.85	25	2.7	66

DRAINAGE AREA 3

A	2.0	0.85	13	3.9	7
A+B	0.9	0.85	13	3.9	3
A+B+C	2.9	0.85	13	3.9	10
A+B+C+D	1.8	0.85	13	3.9	6

DRAINAGE AREA 4

A	21.1	0.57	14	3.6	43
A+B	44.0	0.56	26	2.6	64
A+B+C	53.9	0.56	26	2.6	78
A+B+C+D	57.6	0.56	26	2.6	84

DRAINAGE AREA 5

A	14.7	0.85	19	3.2	40
A+B	17.4	0.85	21	3.0	44
A+B+C	19.9	0.85	23	2.8	47
A+B+C+D	21.8	0.84	25	2.7	49

DRAINAGE AREA 6

A	1.7	0.85	13	3.9	6
B	0.6	0.85	13	3.9	2
C	0.8	0.85	13	3.9	3
D	0.9	0.84	13	3.9	3

TABLE 8: DRAINAGE AREA DISCHARGES EAST OF CANAL

STORM FREQUENCY = 25 year
P_1 = 1.98

DRAINAGE AREA 1

SUB-AREA	ACRES	RUN. COEF.	T_c	I (In/Hr.)	Q (cfs)
A	20.8	0.54	13	4.8	54
A+B	35.4	0.54	16	4.3	82
A+B+C	47.9	0.54	18	4.1	106
A+B+C+D	72.3	0.64	30	3.1	143
A+B+C+D+E	74.6	0.64	30	3.1	148

DRAINAGE AREA 2

A	5.8	0.85	13	4.8	24
A+B	8.4	0.85	14	4.6	33
A+B+C	15.4	0.85	17	4.2	55
A+B+C+D	18.7	0.85	18	4.1	65
A+B+C+D+E	28.6	0.85	25	3.4	83

DRAINAGE AREA 3

A	2.0	0.85	13	4.8	8
B	0.9	0.85	13	4.8	4
C	2.9	0.85	13	4.8	12
D	1.8	0.85	13	4.8	7

DRAINAGE AREA 4

A	21.1	0.57	14	4.6	55
A+B	44.0	0.56	26	3.3	81
A+B+C	53.9	0.56	26	3.3	100
A+B+C+D	57.6	0.56	26	3.3	106

DRAINAGE AREA 5

A	14.7	0.85	19	4.0	50
A+B	17.4	0.85	21	3.8	56
A+B+C	19.9	0.85	23	3.6	61
A+B+C+D	21.8	0.84	25	3.4	62

DRAINAGE AREA 6

A	1.7	0.85	13	4.8	7
B	0.6	0.85	13	4.8	2
C	0.8	0.85	13	4.8	3
D	0.9	0.84	13	4.8	4

TABLE 9: DRAINAGE AREA DISCHARGES EAST OF CANAL

STORM FREQUENCY = 100 year
P_1 = 2.63

DRAINAGE AREA 1

SUB-AREA	ACRES	RUN. COEF.	T_c	I (In/Hr.)	Q (cfs)
A	20.8	0.54	13	6.6	74
A+B	35.4	0.54	16	5.9	113
A+B+C	47.9	0.54	18	5.6	145
A+B+C+D	72.3	0.64	30	4.1	190
A+B+C+D+E	74.6	0.64	30	4.1	196
DRAINAGE AREA 2					
A	5.8	0.85	13	6.6	32
A+B	8.4	0.85	14	6.3	45
A+B+C	15.4	0.85	17	5.7	75
A+B+C+D	18.7	0.85	18	5.6	89
A+B+C+D+E	28.6	0.85	25	4.6	112
DRAINAGE AREA 3					
A	2.0	0.85	13	6.6	11
B	0.9	0.85	13	6.6	5
C	2.9	0.85	13	6.6	16
D	1.8	0.85	13	6.6	10
DRAINAGE AREA 4					
A	21.1	0.57	14	6.3	76
A+B	44.0	0.56	26	4.5	111
A+B+C	53.9	0.56	26	4.5	136
A+B+C+D	57.6	0.56	26	4.5	145
DRAINAGE AREA 5					
A	14.7	0.85	19	5.4	68
A+B	17.4	0.85	21	5.1	74
A+B+C	19.9	0.85	23	4.8	81
A+B+C+D	21.8	0.84	25	4.6	84
DRAINAGE AREA 6					
A	1.7	0.85	13	6.6	9
B	0.6	0.85	13	6.6	3
C	0.8	0.85	13	6.6	4
D	0.9	0.84	13	6.6	5

V. CONCEPTUAL DRAINAGE DESIGN

Utilizing the results from the hydrology study, detailed earlier in this report and summarized in Tables 4 through 9 and Figure 4, various concepts were considered to develop a storm drainage system capable of conveying the 100-year frequency storm. The design criteria as set forth in the CBA design contract and the City of Scottsdale drainage manual, Section 3-501 "Design Procedures and Criteria - Section 3 - Design of Facilities to Manage Stormwater Runoff", are as follows:

Major Collector, Minor Arterial and Major Arterial
(McDowell Road, Scottsdale Road, 68th Street and Miller Road)

a. Street flow width limited to maintain a 12 foot dry lane in both directions during a 100-year storm.
b. Retain 100-year storm runoff within the public right-of-way to a depth not to exceed 8 inches above the gutter line.

Local Residential, Local Collector, Local Industrial, Local Commercial, and Minor Collector
(All other streets)

a. Street flow width shall not exceed 12 feet in 2-year storm.
b. Retain 100-year storm in public right-of-way not to exceed 8 inches in depth above gutter line.

The above criteria were incorporated into the hydrology and drainage concepts presented in this report.

West of the Cross Cut Canal, per the Scope of Work, it is proposed to provide street drainage on McDowell Road through the use of catch basin scuppers emptying into existing side drainage channels. Improvements on 64th Street will include the addition of some culverts to replace the existing dip sections. The locations of existing and proposed culvert crossings are shown on Map 2.

East of the Cross Cut Canal, the original Scope of Work called for an underground storm drain system starting at 67th Place and extending east to Scottsdale Road. At Scottsdale Road the intent was to intercept all drainage that results west of Scottsdale Road and convey it southward through an existing storm drain system to Belleview Street then east on Belleview before outletting to the Indian Bend Wash at Roosevelt Street (Map 2). A 36" storm drain presently picks up runoff resulting in a dip section at the intersection of Scottsdale Road and Palm Lane and carries it south to the existing 60" storm drain in McDowell Road. A new independant storm drain system was then proposed from 73rd Street, eastward along McDowell, discharging to Indian Bend Wash near the existing McDowell Road bridge.

Under free flowing conditions the existing 60" storm drain at Scottsdale Road and McDowell Road has a capacity of 230 cfs. Under pressure flow (surcharged) conditions the maximum capacity of the whole system is approximately 280 cfs (Appendix V). A flow rate of 40 cfs is contributed from the 36" storm drain originating at Palm Lane, 132 cfs from Scottsdale Road and 176 cfs from McDowell Road. The total contribution of 348 cfs thus exceeds the capacity of the existing 60" storm drain.

In addition, a later decision was made to intercept storm runoff from Scottsdale Road north of Palm Lane via a new Scottsdale Road system and convey it south to the storm system being design by CBA. Design of this section of storm drain is to be handled by Ellis-Murphy Inc., consulting engineers. The resulting discharges reaching Scottsdale Road are addressed in a report by Ellis-Murphy entitled "Drainage Report for Scottsdale Road from McDowell Road to Osborn Road," October 1985 (See Appendix VI for effective pipe discharges).

Several alternatives were considered in an attempt to solve the resulting drainage problem at the intersection of Scottsdale Road and McDowell Road and to provide a storm drain outfall for Scottsdale Road. The most feasible five alternatives are presented in Figure 5 and summarized as follows:

Plan A: Construct storm drain system north on Scottsdale parallel to the existing 36" storm drain and convey 132 cfs eastward to a new McDowell Road system.

Plan B: Replace the existing 36" storm drain on Scottsdale Road and replace with a larger diameter pipe, where necessary. This could then either convey all flow east on McDowell Road or interconnect with the existing storm drain system.

Plan C: Construct a storm drain system north on Scottsdale Road parallel to the existing 36" storm drain and interconnect with the existing system on Scottsdale Road. The 36" pipe would then convey flows east on McDowell Road.

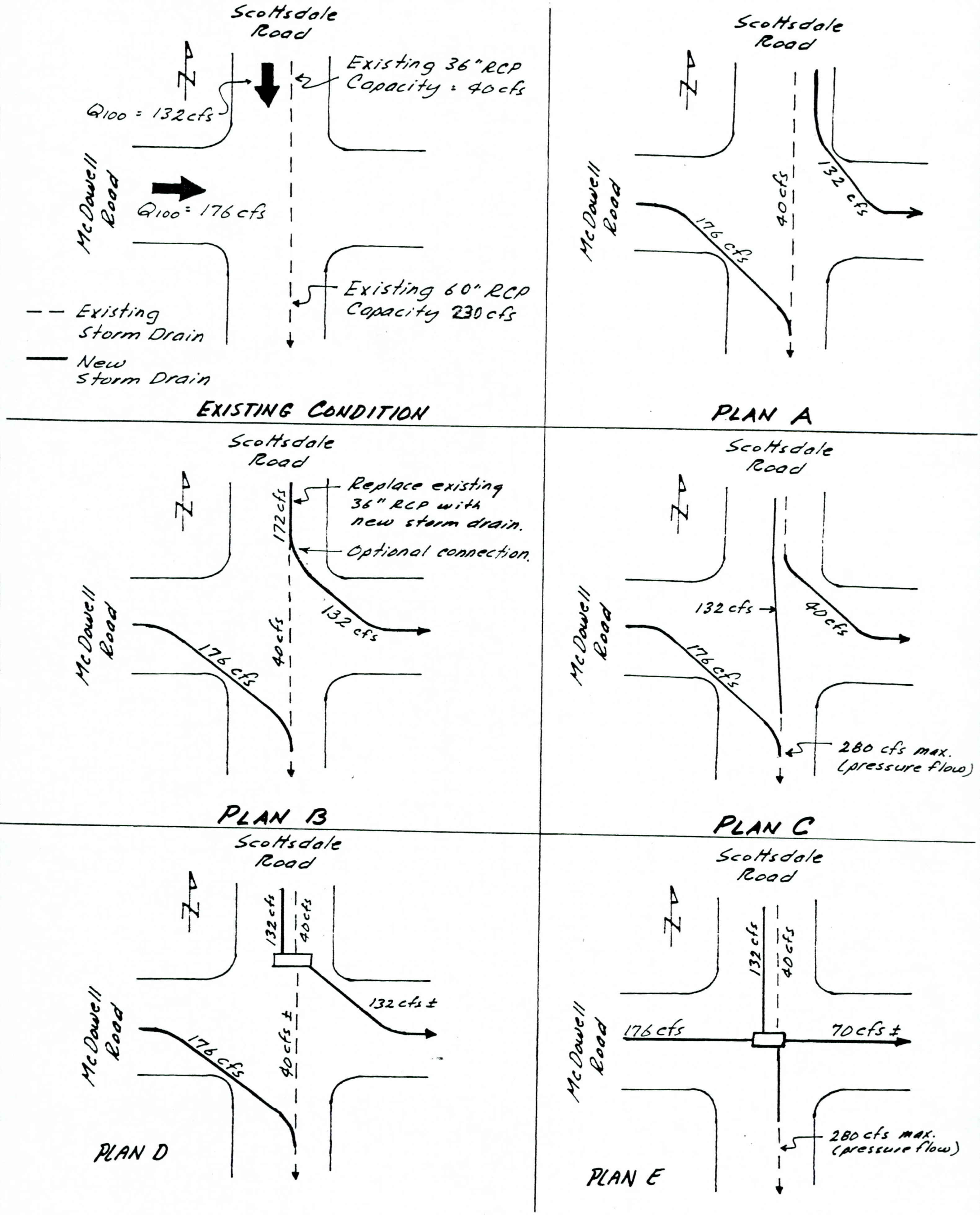
Plan D: Plan D is similar to Plan B except the new storm drain is connected parallel to the existing 36" pipe and a junction structure is constructed north of the intersection.

Plan E: Interconnect the new and existing storm drain systems with a junction box at the intersection of Scottsdale Road and McDowell Road.

After considering the above options, each in regard to construction, storm drain capacities and traffic control, it was decided that Plan A offered the greatest number of advantages while allowing for ease of construction. The existing 36" stormdrain that presently collects drainage at Palm Lane thus remains in use and functional while a totally new and independent storm drain system will be constructed parallel to it out side of the major traffice lanes. Some cross-connection of catch basin connector pipes may be necessary due to lack of clearance but this should prove acceptable and provide a balancig effect for each hydraulic gradeline. This alternate and the corresponding pipe sizes necessary to handle the respective flows are presented on Map 2.

FIGURE 5:

SCOTTSDALE/McDOWELL ROAD STORM DRAIN ALTERNATIVES.



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Cella Barr Associates; March 1986, Storm Drainage System for McDowell Road Improvements, Scottsdale, Arizona, Part 2-Hydraulic Design Report.

City of Scottsdale, Arizona Community Development Department; Oct. 3, 1984; Design procedures and criteria section 2 drainage report preparation.

City of Scottsdale, Arizona Community Development Department; Oct. 3, 1984; Design procedures and criteria section 3 design of facilities to manage stormwater runoff.

City of Scottsdale, Arizona Planning Department; Zoning map (current to Aug. 22, 1984).

Collar, Williams and White Engineering, Inc.; 1973; Drainage Report for City of Scottsdale on McDowell Road - 64th Street to Scottsdale Road.

Ellis-Murphy, Inc.; October 1985 Drainage Report for Scottsdale Road from McDowell Road to Osborn Road.

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APPENDIX I:

Time of Concentration Calculations
for Drainage Areas 1 through 7 Located
West of the Cross Cut Canal and Southwest
of the Intersection of 64th Street and McDowell Road.
(Reference Map 1)

TIME OF CONCENTRATION
WEST OF CANAL

Area 1 and 2

Area = 0.398 sq. mi.

Length = 550 ft.

Elevation: High = 1400

Low = 1340

$Slope_1$ = 0.11 ft/ft

$$T_{c1} = \frac{550^{1.15}}{7700(60)^{.38}}$$

T_{c1} = 0.039 Hours

$Length_2$ = 2100 ft.

$Elevation_2$: High = 1340

Low = 1300

$Slope_2$ = 0.019 ft/ft

$$T_{c2} = \frac{2100^{1.15}}{7700(40)^{.38}}$$

T_{c2} = 0.211 Hours

$Length_3$ = 2650

$Elevation_3$: High = 1300

Low = 1270

$Slope_3$ = 0.011 ft/ft

$$T_{c3} = \frac{2650^{1.15}}{7700(30)^{.38}}$$

T_{c3} = 0.31 Hours

Gutter Flow (See Attached Cross-Section)

$V = Q/A$

$V = \frac{13.5}{9} = 1.5$ fps

$$T_{c4} = \frac{Dist}{V} = \frac{5300}{1.5 \times 3600}$$

T_{c4} = 0.98

$T_c = T_{c1} + T_{c2} + T_{c3} + T_{c4}$ = 1.54 Hours

Area 2

Area = 0.012 sq. mi.
Length = 1020 ft
Elevation: High = 1310
Low = 1290
Slope = 0.02 ft/ft

$$T_c = \left(\frac{1020}{7700(20)^{.38}}\right)^{1.15}$$

T_c = 0.12 Hours
T_c used in report = 0.17 Hours

Area 3

Area = 0.048 sq. mi.
Length = 2920 ft.
Elevation: High = 1340
Low = 1287
Slope = 0.018 ft/ft

$$T_c = \left(\frac{2920}{7700(53)^{.38}}\right)^{1.15}$$

T_c = 0.28 Hours

Area 3 + 3A

Area = 0.054 sq. mi.
Length = 3600 ft
Elevation: High = 1340
Low = 1274
Slope = 0.018 ft/ft

$$T_c = \left(\frac{3600}{7700(66)^{.38}}\right)^{1.15}$$

T_c = 0.32 Hours

Area 4

Area = 0.029 sq. mi.
Length = 3160 ft
Elevation: High = 1350
Low = 1284
Slope = 0.021 ft/ft

$$T_c = \left(\frac{3160}{7700(66)^{.38}}\right)^{1.15}$$

T_c = 0.28 Hours

Area 4A

Area = 0.0078 sq. mi.
Length = 720 ft.
Elevation: High = 1,550
Low = 1,340
Slope = 0.29 ft/ft

$$T_c = \frac{720^{1.15}}{7700(210)^{.38}}$$

T_c = 0.033 Hours
T_c used in report = 0.28

Area 4B

Area = 0.0019 sq. mi.
Length = 420 ft.
Elevation: High = 1,450
Low = 1,340
Slope = 0.26 ft/ft

$$T_c = \frac{420^{1.15}}{7700(110)^{.38}}$$

T_c = 0.022 Hours
T_c used in report = 0.28

Area 4C

Area = 0.0119 sq. mi.
Length = 1,120 ft.
Elevation: High = 1,660
Low = 1,335
Slope = 0.29 ft/ft

$$T_c = \frac{1{,}120^{1.15}}{7700(325)^{.38}}$$

T_c = 0.046 Hours
T_c used in report = 0.28

Area 4D

Area = 0.0058 sq. mi.
Length = 480 ft.
Elevation: High = 1,325
Low = 1,305
Slope = 0.042 ft/ft

$$T_c = \frac{480^{1.15}}{7700(20)^{.38}}$$

T_c = 0.05 Hours
T_c used in report = 0.28

Area 4 + 3A

Area = 0.035 sq. mi.

Length = 3750 ft.

Elevation: High = 1350

Low = 1274

Slope = 0.02 ft/ft

$$T_c = \frac{3750}{7700(76)^{.38}}^{1.15}$$

T_c = 0.32 Hours

Area 5

Area = 0.0062 sq. mi.

Length = L_1 = 450 ft. L_2 = 480 ft.

Elevation: $High_1$ = 1,340 $High_2$ = 1,295

Low_1 = 1,305 Low_2 = 1,286

Slope = S_1 = 0.1 ft/ft S_2 = 0.012 ft/ft

$$T_{c1} = \frac{450}{7700(45)^{.38}}^{1.15} \qquad T_{c2} = \frac{480}{7700(9)^{.38}}^{1.15}$$

$T_c = T_{c1} + T_{c2}$ = 0.1 Hours

T_c used in report = 0.17 Hours

Area 6

Area = 0.0062 sq. mi.

Length = 660 ft.

Elevation: High = 1,305

Low = 1,281

Slope = 0.036 ft/ft

$$T_c = \frac{660}{7700(24)^{.38}}^{1.15}$$

T_c = 0.068 Hours

T_c used in report = 0.17 Hours

Area 7

Area = 0.0111 sq. mi.

Length = 800 ft.

Elevation: High = 1,340

Low = 1,279

Slope = 0.076 ft/ft

$$T_c = \frac{800}{7700(61)^{.38}}^{1.15}$$

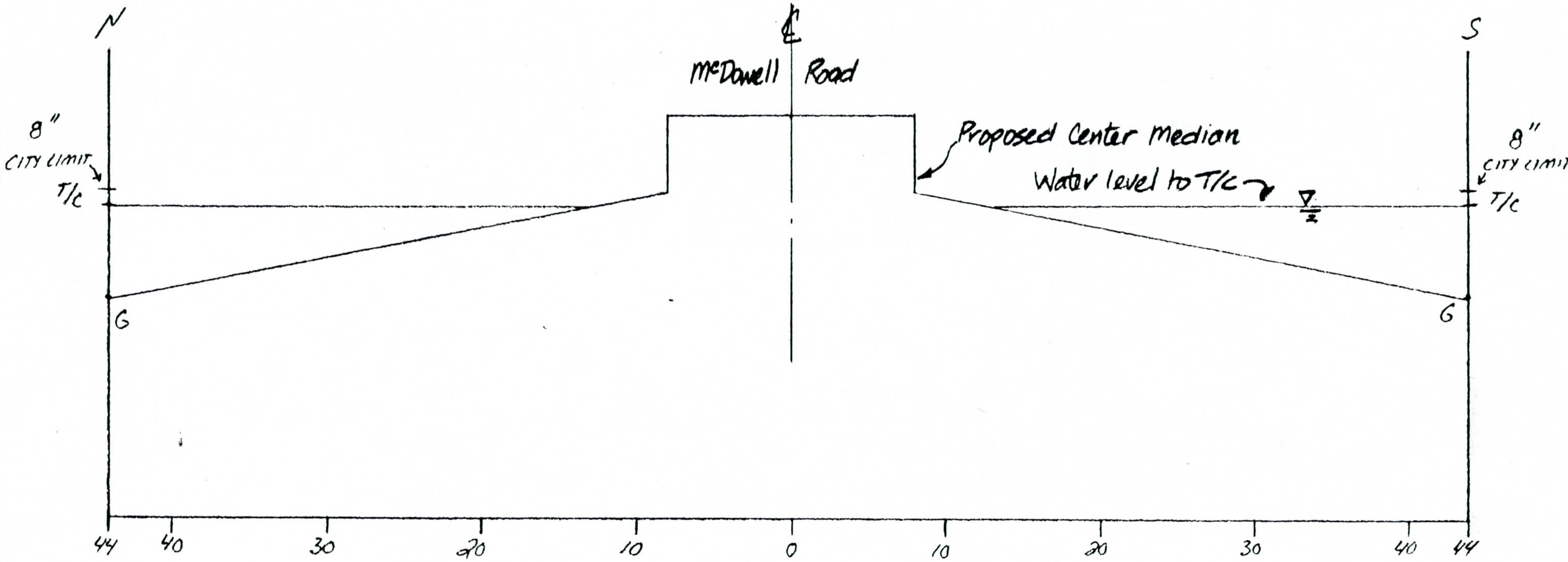
T_c = 0.059 Hours

T_c used in report = 0.17 Hours

APPENDIX II:

Cross Sections and Street Capacity
Calculations For Streets In The
McDowell Road Study Area.

McDowell Rd. STREET CAPACITY CALCULATION



$Q = 0.56\ z\, d^{8/3}\, S^{1/2} / N$

SLOPE = 0.011

N = 0.015

d = .6 ft

T = 31'

z = T/d = 51.6

$$Q = \frac{0.56 \times 51.6\,(.6)^{8/3}\,(0.011)^{1/2}}{0.015}$$

Q = 52 ✓ 52 x 2 = 104 cfs

i.e. Estimated max. possible street flow = 104cfs

TYPICAL McDOWELL RD. X-SECTION

AFTER IMPROVEMENT

SCALE:

HORIZ. 1" = 10'

VERT. 1" = 1.0'

DESIGN NOTES AND COMPUTATIONS

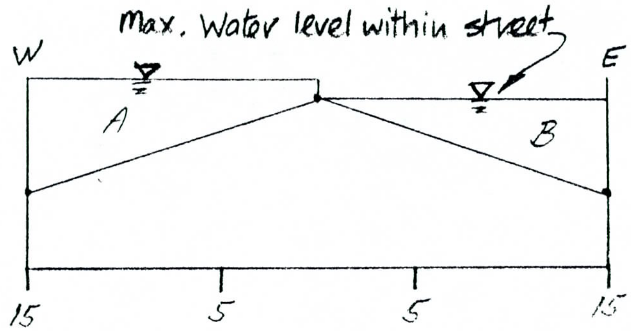
SUBJECT: 66th St. STREET CAPACITY CALCULATION

JOB NUMBER

NORTH

LENGTH = 5100'

GUTTER FLOW 66th STREET



A

$Q = 1.49\,A R^{2/3} S^{1/2} / N$

SLOPE = 0.001

N = 0.015

A = 5.25 sq ft

P = 15.7 ft

R = A/P = 0.33

$$Q = \frac{1.49 \times 5.25 (0.33)^{2/3} (0.001)^{1/2}}{0.015}$$

Q = 7.9 cfs

B

$Q = 0.56\,Z d^{8/3} S^{1/2} / N$

SLOPE = 0.001

N = 0.015

d = 0.5 ft.

T = 15 ft

Z = T/d = 30

$$Q = \frac{0.56 \times 30 (0.5)^{8/3} (0.001)^{1/2}}{0.015}$$

Q = 5.6 cfs

TOTAL = 13.5 cfs

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DATE

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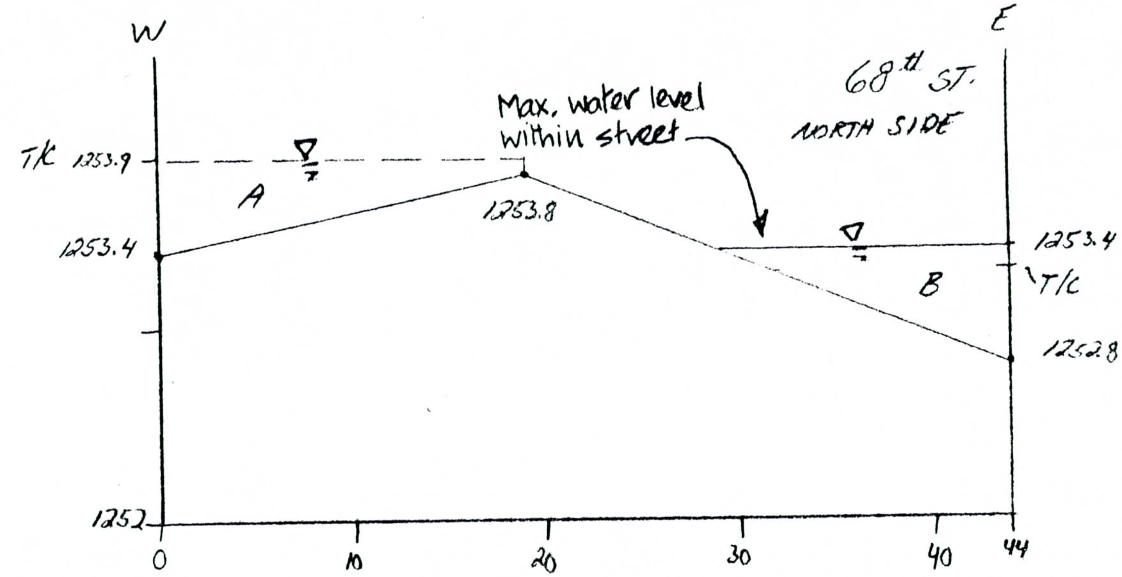
DESIGN NOTES AND COMPUTATIONS

SUBJECT: 68th St. STREET CAPACITY CALCULATION

JOB NUMBER: NORTH

PREPARED BY | DATE | CHECKED BY | SHEET NO. OF



TAKEN FROM AIR PHOTO TOPOGRAPHY

SCALE:
HORIZ. 1" = 10'
VERT. 1" = 1.0'

A

$Q = 1.49\, A R^{2/3} S^{1/2} / N$

SLOPE = 0.0026
N = 0.015
AREA = 5.7 ft²
P = 19.6
R = A/P = 0.29

$$Q = \frac{1.49 \times 5.7\, (0.29)^{2/3} (0.0026)^{1/2}}{0.015}$$

Q = 12.6 cfs ✓

B

$Q = 0.56\, Z\, d^{8/3} S^{1/2} / N$

SLOPE = 0.0026
N = 0.015
d = .6 ft
T = 15 ft
Z = T/d = 25

$$Q = \frac{0.56 \times 25\, (.6)^{8/3} (0.0026)^{1/2}}{0.015}$$

Q = 12.2 cfs

TOTAL = 25 cfs

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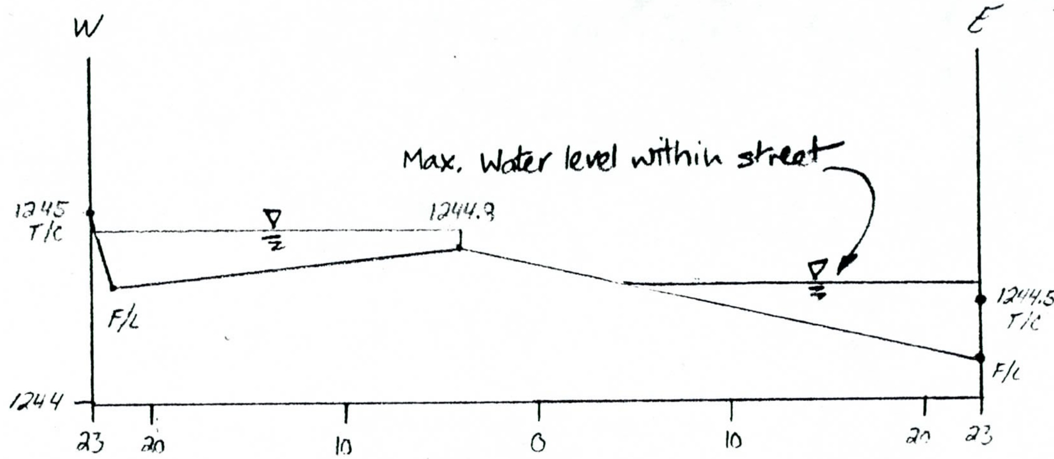
DESIGN NOTES AND COMPUTATIONS

SUBJECT: 69th St. STREET CAPACITY CALCULATION

JOB NUMBER: NORTH

TAKEN FROM SURVEY NOTES. (STA. 4+00)

SCALE:
HORIZ. 1" = 10'
VERT. 1" = 1.0'



A

$Q = 1.49 A R^{2/3} S^{1/2} / N$

SLOPE = 0.003
N = 0.015
AREA = 4.5 ft²
P = 18.4 ft
R = A/P = 0.24

$$Q = \frac{1.49 \times 4.5 (0.24)^{2/3} (0.003)^{1/2}}{0.015}$$

Q = 9.5 cfs

B

$Q = 0.56 Z d^{8/3} S^{1/2} / N$

SLOPE = 0.0038
N = 0.015
d = .4 ft
T = 18 ft
Z = T/d = 45

$$Q = \frac{0.56 \times 45 (.4)^{8/3} (0.0038)^{1/2}}{0.015}$$

Q = 9 cfs

TOTAL = 18. cfs

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DESIGN NOTES AND COMPUTATIONS

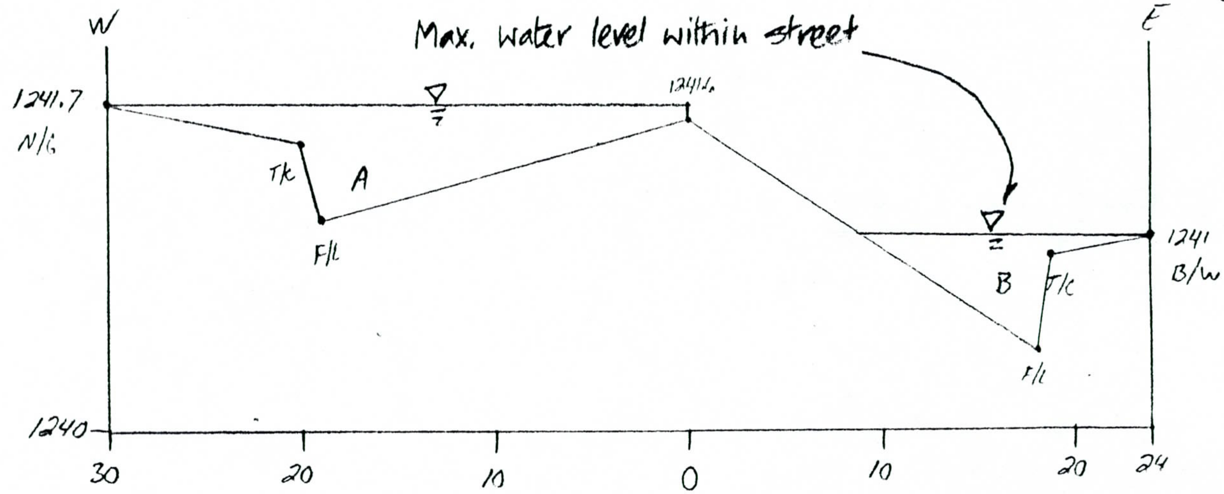
SUBJECT: 70th St. STREET CAPACITY CALCULATION

NORTH

JOB NUMBER

TAKEN FROM SURVEY NOTES. (STA. 4+00)

SCALE:
HORIZ. 1" = 10'
VERT. 1" = 1.0'



A

$Q = 1.49 A R^{2/3} S^{1/2} / N$

SLOPE = 0.0018

N = 0.015

AREA = 7.3 ft^2

P = 30 ft

$R = A/P = 0.24$

$$Q = \frac{1.49 \times 7.3 (0.24)^{2/3} (0.0018)^{1/2}}{0.015}$$

Q = 11.9 cfs

B

$Q = 0.56\, z\, d^{8/3} S^{1/2} / N$

SLOPE = 0.0018

N = 0.015

d = .6 ft

T = 10 ft

$z = T/d = 16.7$

$$Q = \frac{0.56 \times 16.7 (.6)^{8/3} (0.0018)^{1/2}}{0.015}$$

Q = 6.8 cfs

TOTAL = 19 cfs

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DESIGN NOTES AND COMPUTATIONS

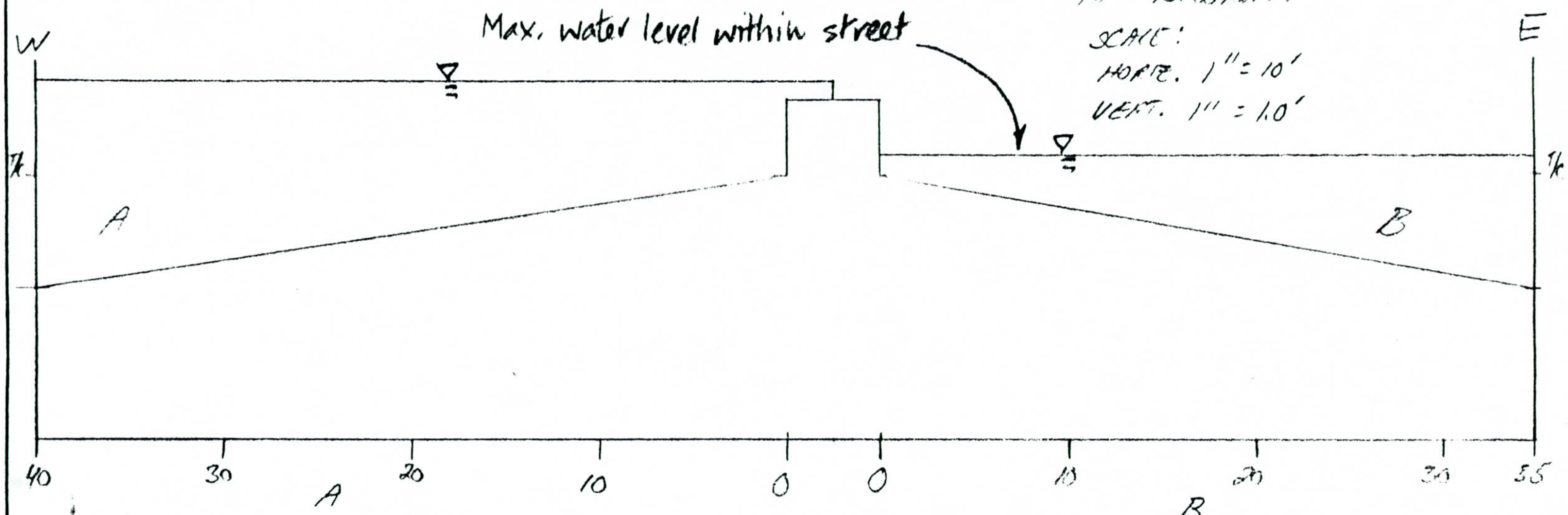
SUBJECT: Scottsdale Rd. STREET CAPACITY CALCULATION

JOB NUMBER

NORTH

TAKEN FROM AIR PHOTO TOPOGRAPHY.

SCALE:
HORIZ. 1" = 10'
VERT. 1" = 1.0'



A	B
$Q = 1.49 A R^{2/3} S^{1/2} / N$	$Q = 1.49 A R^{2/3} S^{1/2} / N$
SLOPE = 0.002	SLOPE = 0.002
N = 0.015	N = 0.015
AREA = 34 ft²	AREA = 14
P = 44.1	P = 43
R = A/P = 0.77	R = A/P = 0.32
$Q = \frac{1.49 \times 34 (0.77)^{2/3} (0.002)^{1/2}}{0.015}$	$Q = \frac{1.49 \times 14 (0.32)^{2/3} (0.002)^{1/2}}{0.015}$
Q = 127 cfs	Q = 29

TOTAL = 156 cfs

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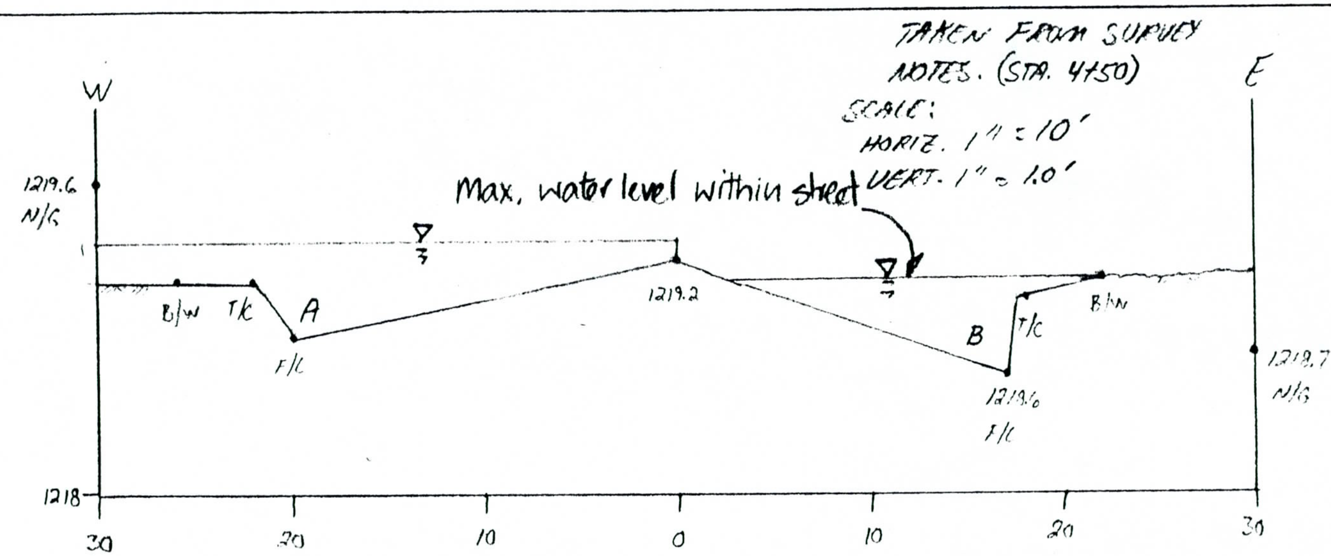
DESIGN NOTES AND COMPUTATIONS

SUBJECT: 74th St. STREET CAPACITY CALCULATION

JOB NUMBER: NORTH



A

$$Q = 1.49 A R^{2/3} S^{1/2} / N$$

SLOPE = 0.0013

N = 0.015

AREA = 8.1 ft^2

P = 30.6 ft

R = A/P = 0.26

$$Q = \frac{1.49 \times 8.1 (0.26)^{2/3} (0.0013)^{1/2}}{0.015}$$

Q = 11.8 cfs ✓

B

$$Q = 0.56\, z\, d^{8/3} S^{1/2} / N$$

SLOPE = 0.0013

N = 0.015

d = .5 ft

T = 15 ft

Z = T/d = 30

$$Q = \frac{0.56 \times 30 (.5)^{8/3} (0.0013)^{1/2}}{0.015}$$

Q = 6.~~8~~ 4 cfs

TOTAL = ~~30~~ 18 cfs

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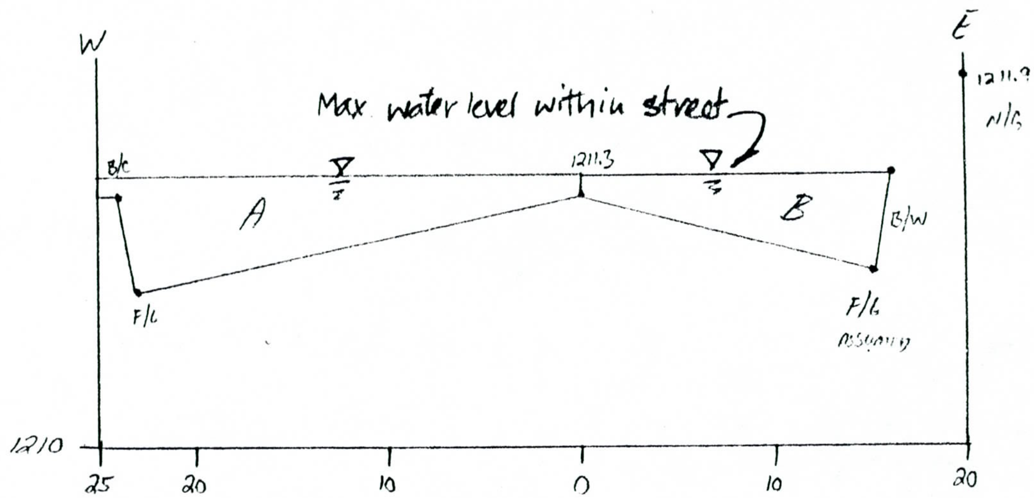
DESIGN NOTES AND COMPUTATIONS

SUBJECT: **Miller Rd.** STREET CAPACITY CALCULATION

JOB NUMBER: NORTH

TAKEN FROM SURVEY NOTES. (STA. 4+00)

SCALE:
HORIZ. 1" = 10'
VERT. 1" = 1.0'



A

$Q = 1.49 A R^{2/3} S^{1/2} / N$

SLOPE = 0.0024
N = 0.015
AREA = 8.6 ft
P = 24.7
R = A/P = 0.35

$$Q = \frac{1.49 \times 8.6 (0.35)^{2/3} (0.0024)^{1/2}}{0.015}$$

Q = 20.8 cfs

B

$Q = 1.49 A R^{2/3} S^{1/2} / N$

SLOPE = 0.0024
N = 0.015
AREA = 4.8 ft
P = 16.6 ft
R = A/P = 0.29

$$Q = \frac{1.49 \times 4.8 (0.29)^{2/3} (0.0024)^{1/2}}{0.015}$$

Q = 10.2

TOTAL = 31 cfs

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5062 N. 19th Avenue, Phoenix, Arizona 85015

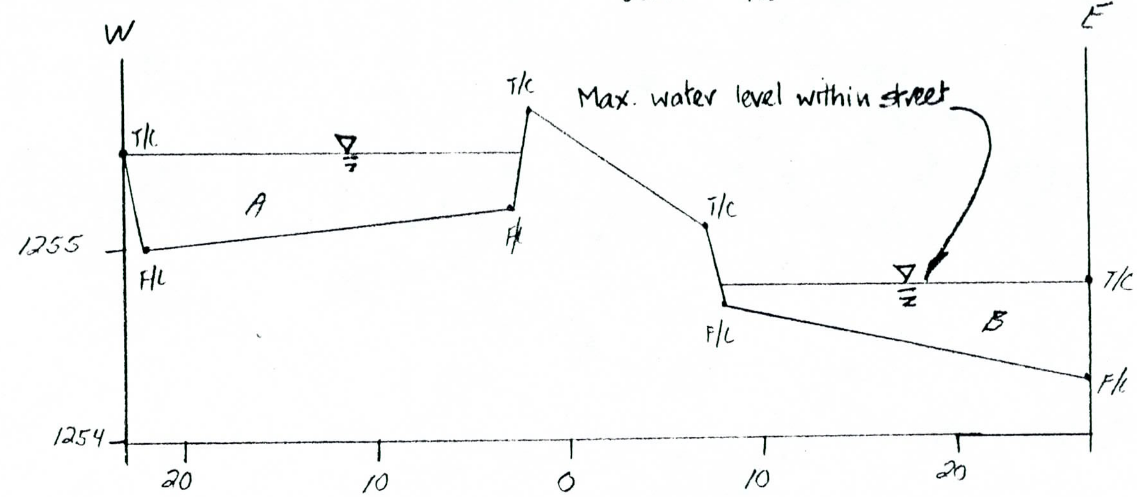
DESIGN NOTES AND COMPUTATIONS

SUBJECT: 67th Pl. STREET CAPACITY CALCULATION

JOB NUMBER SOUTH

SCALE:
HORIZ. 1" = 10'
VERT. 1" = 1.0'

TAKEN FROM SURVEY NOTES. (STA. 1+41)



$$Q = 1.49 A R^{2/3} S^{1/2} / N$$

A

SLOPE = 0.013

N = 0.015

A = 8.4 ft²

P = 21.8 ft

R = A/P = 0.38

$$Q = \frac{1.49 \times 8.4 (0.38)^{2/3} (0.013)^{1/2}}{0.015}$$

Q = 49.9 cfs

B

SLOPE = 0.013

N = 0.015

A = 5.7

P = 19.6

R = A/P = 0.29

$$Q = \frac{1.49 \times 5.7 (0.29)^{2/3} (0.013)^{1/2}}{0.015}$$

Q = 28.3 cfs

TOTAL = 79 cfs

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CELLA BARR ASSOCIATES
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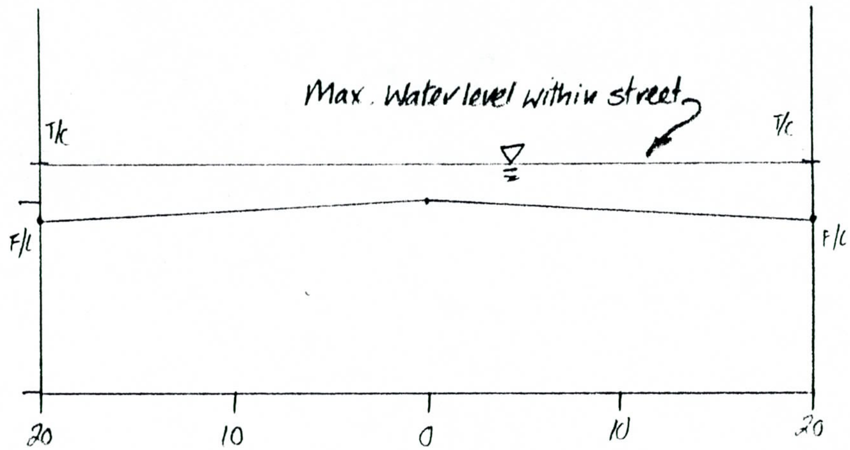
DESIGN NOTES AND COMPUTATIONS

SUBJECT: 68th St. STREET CAPACITY CALCULATION

JOB NUMBER: SOUTH

TAKEN FROM SURVEY NOTES AND AIR PHOTO TOPOGRAPHY.

SCALE:
HORIZ. 1" = 10'
VERT. 1" = 1.0'



$$Q = 1.49\,A R^{2/3} S^{1/2}/N$$

SLOPE = 0.004

$N = 0.015$

$A = 10\ ft^2$

$P = 40.6$

$R = A/P = 0.25$

$$Q = \frac{1.49 \times 10\,(0.25)^{2/3}(0.004)^{1/2}}{0.015}$$

$Q = 25$ cfs

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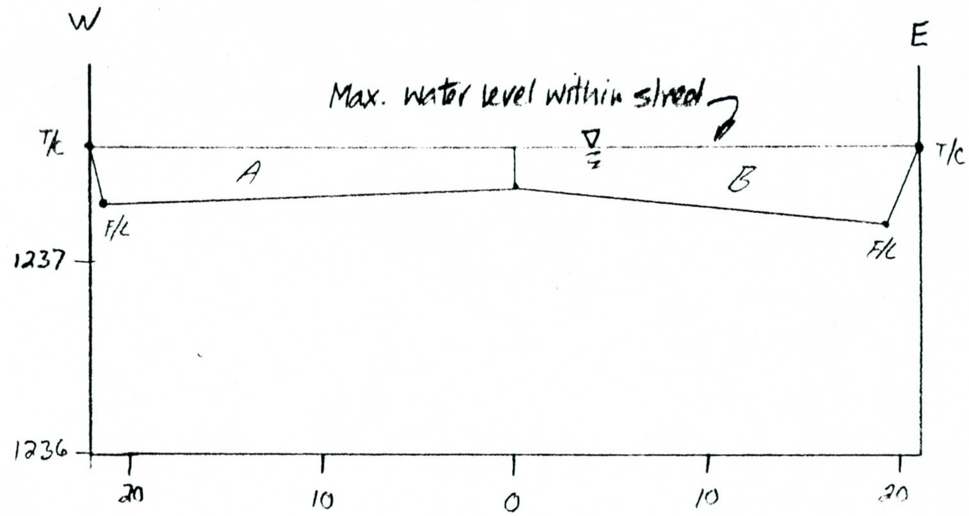
DESIGN NOTES AND COMPUTATIONS

SUBJECT: 70th St. STREET CAPACITY CALCULATION

JOB NUMBER: SOUTH

TAKEN FROM SURVEY NOTES. (STA. 4+50)

SCALE:
HORIZ. 1" = 10'
VERT. 1" = 1.0'



$Q = 1.49\, A R^{2/3} S^{1/2} / N$

A

SLOPE = 0.0039
N = 0.015
A = 5.5 ft²
P = 22.5 ft.
R = A/p = 0.24

$$Q = \frac{1.49 \times 5.5\,(0.24)^{2/3}\,(0.0039)^{1/2}}{0.015}$$

Q = 13.2 cfs

B

SLOPE = 0.0039
N = 0.015
A = 6.3 ft²
P = 21.6 ft
R = A/p = 0.29

$$Q = \frac{1.49 \times 6.3\,(0.29)^{2/3}\,(0.0039)^{1/2}}{0.015}$$

Q = 17.1 cfs

TOTAL = 30 cfs

SLOPE:
X-SECTION 1+67 - 4+50
1238.5 - 1237.4 = 1.1
1.1 / 283 = 0.0039

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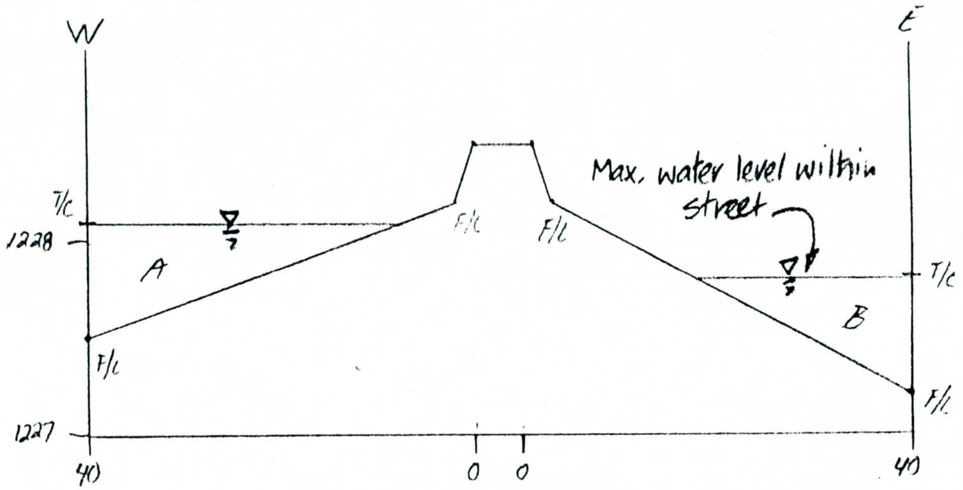
DESIGN NOTES AND COMPUTATIONS

SUBJECT: Scottsdale Rd. STREET CAPACITY CALCULATION

JOB NUMBER: SOUTH

TAKEN FROM AIR
PHOTO TOPOGRAPHY

SCALE:
HORIZ. 1" = 20'
VERT. 1" = 1.0'



$$Q = 0.56\, z d^{8/3} S^{1/2} / N$$

A

SLOPE = 0.0043

N = 0.015

d = .6 ft

T = 32 ft

Z = T/d = 53.3

$$Q = \frac{0.56 \times 53.3 (.6)^{8/3} (0.0043)^{1/2}}{0.015}$$

Q = 33.4 cfs

B

SLOPE = 0.0043

N = 0.015

d = .6 ft

T = 22 ft

Z = T/d = 36.7

$$Q = \frac{0.56 \times 36.7 (.6)^{8/3} (0.0043)^{1/2}}{0.015}$$

Q = 23 cfs

TOTAL = 56 cfs

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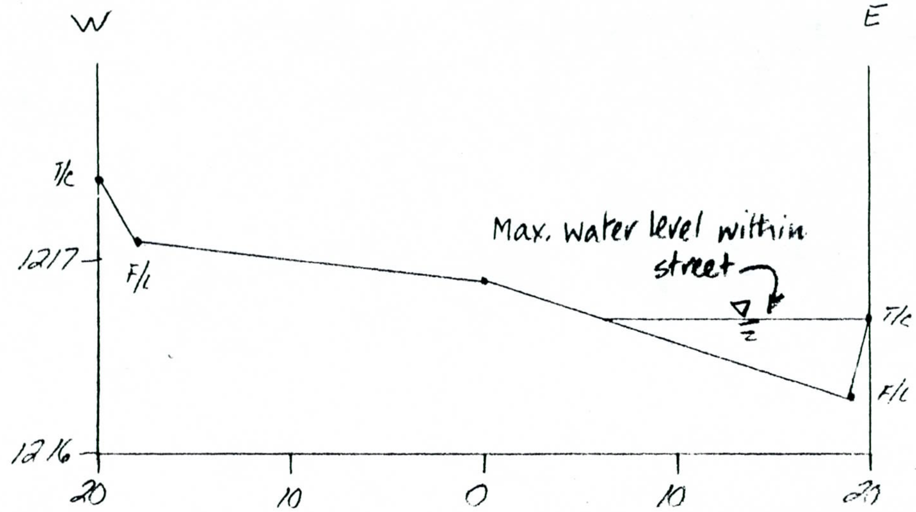
DESIGN NOTES AND COMPUTATIONS

SUBJECT: **74th St. STREET CAPACITY CALCULATION**

JOB NUMBER **SOUTH**

TAKEN FROM SURVEY NOTES. (STA. 2+00)

SCALE:
HORIZ. 1" = 10'
VERT. 1" = 1.0'



$$Q = 0.56\, z d^{8/3} S^{1/2} / N$$

SLOPE = 0.0072
N = 0.015
d = .4
T = 14
z = T/d = 35

$$Q = \frac{0.56 \times 35 (.4)^{8/3} (0.0072)^{1/2}}{0.015}$$

Q = 10 cfs

SLOPE:
X-SECTION 1+01 – 4+50
1218 - 1215.5 = 2.5
2.5 / 349 = 0.0072

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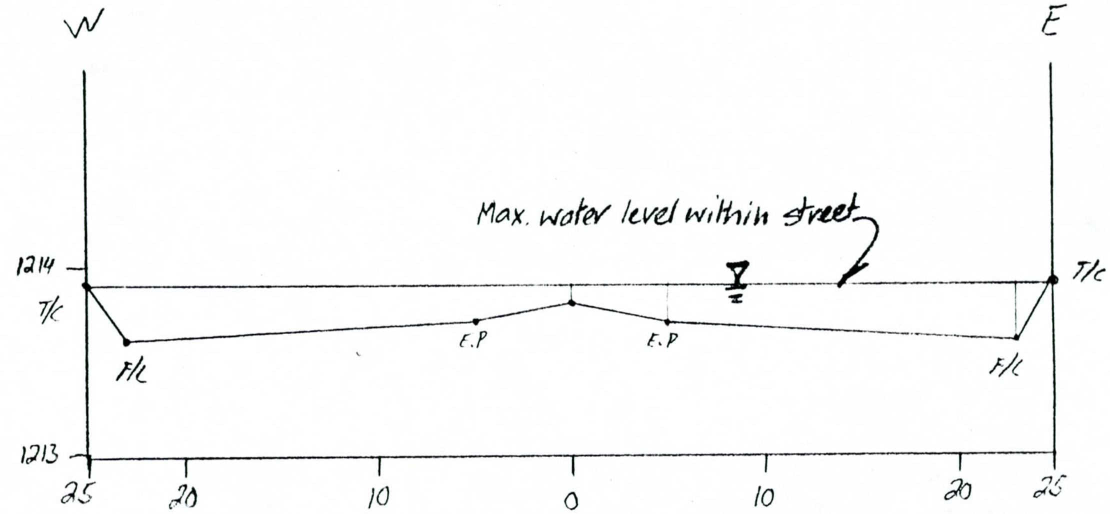
DESIGN NOTES AND COMPUTATIONS

SUBJECT: **75th St.** STREET CAPACITY CALCULATION

JOB NUMBER: SOUTH

TAKEN FROM SURVEY NOTES. (STA. 4+50)

SCALE:
HORIZ. 1" = 10'
VERT. 1" = 1.0'



$$Q = 1.49\, A R^{2/3} S^{1/2} / N$$

SLOPE = 0.01

$N = 0.015$

$A = 10.56\ ft^2$

$P = 46.4\ ft$

$R = A/P = 0.23$

$$Q = \frac{1.49 \times 10.56 (0.23)^{2/3} (0.01)^{1/2}}{0.015}$$

$Q = 39$ cfs

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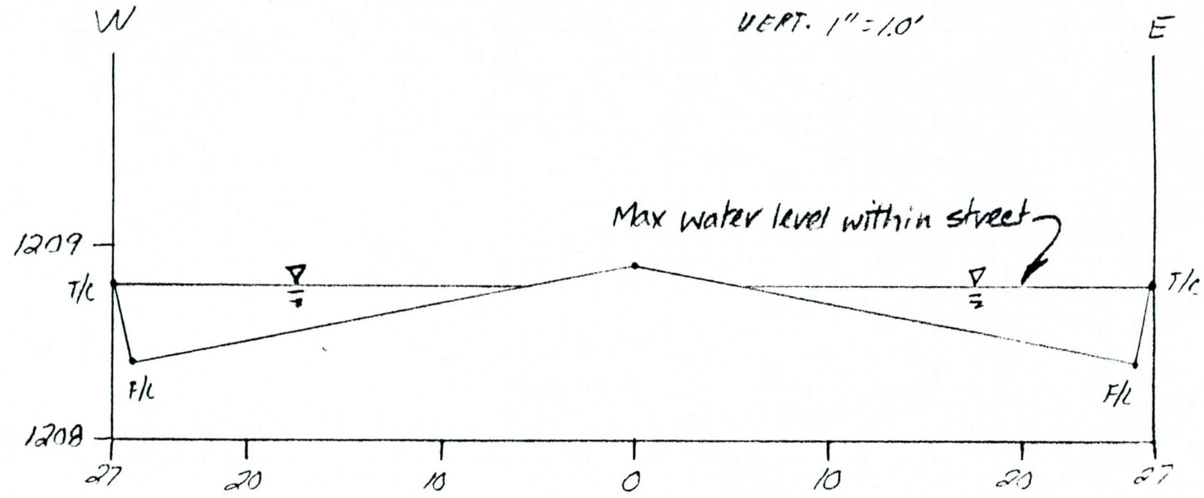
DESIGN NOTES AND COMPUTATIONS

SUBJECT: Miller Rd. STREET CAPACITY CALCULATION

JOB NUMBER: SOUTH

SCALE:
HORIZ. 1" = 10'
VERT. 1" = 1.0'

TAKEN FROM AIR PHOTO TOPOGRAPHY



$$Q = 0.56\, z\, d^{8/3} S^{1/2} / N$$

SLOPE = 0.004
N = 0.015
d = .4
T = 21
Z = T/d = 52.5

$$Q = \frac{0.56 \times 52.5\,(.4)^{8/3}\,(0.004)^{1/2}}{0.015}$$

Q = 10.8
10.8 × 2 = 22 cfs

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APPENDIX III:

Time of Concentration Calculations
For Drainage Areas 1 Through 6 Located
East Of The Cross Cut Canal.
(Reference Map 1)

TIME OF CONCENTRATION
DRAINAGE AREA 1

1-A
20.8 Acres (In A)
Distance = 1030 ft. (E-W)
Slope = 0.0092 ft/ft

$V = 54\ S^{1/2}$ $\frac{1030}{5.2 \times 60} = 3.3 + 10 = 13.3$ Min
$= 54(0.0092)^{1/2}$

$= 5.2$ fps

Tc = 13 Min i/2 = 2.3 i/10 = 3.9 i/25 = 4.8 i/100 = 6.6

1-B = A + B
14.6 Acres (In B)
Distance = 1890 ft. (E-W) $\frac{1890}{5.2 \times 60} = 6 + 10 = 16$ Min
Slope = 0.0092 ft/ft

Tc = 16 Min i/2 = 2.1 i/10 = 3.5 i/25 = 4.3 i/100 = 5.9

1-C = A + B + C
12.5 Acres (In C)
Distance = 2350 ft. (E-W) $\frac{2350}{5.2 \times 60} = 7.5 + 10 = 17.5$ Min
Slope = 0.0092 ft/ft

Tc = 18 Min i/2 = 2.0 i/10 = 3.1 i/25 = 4.1 i/100 = 5.6

1-D = A + B + C + D + E
26.7 Acres (In D and E)
$Distance_1$ = 3660 ft. (E-W) $\frac{3660}{5.2 \times 60} = 11.7$
$Slope_1$ = 0.0092 ft/ft

$Distance_2$ = 1180 ft (N-S)
$Slope_2$ = 0.002 ft/ft

$V = 54\ S^{1/2}$ $\frac{1180}{2.4 \times 60} = 8.2 + 11.7 + 10 = 29.9$ Min
$= 54(0.002)^{1/2}$

$= 2.4$ fps

Tc = 30 Min i/2 = 1.5 i/10 = 2.4 i/25 = 3.1 i/100 = 4.1

TIME OF CONCENTRATION
DRAINAGE AREA 2

2-A
5.8 Acres (In A)
Distance = 880 ft. (E-W)
Slope = 0.0092 ft/ft

$V = 54\ S^{1/2}$
$= 54\ (0.0092)^{1/2}$

$= 5.2$ fps

$\frac{880}{5.2 \times 60} = 2.8 + 10 = 12.8$ Min

Tc = 13 Min
$i/2 = 2.3$ $i/10 = 3.9$ $i/25 = 4.8$ $i/100 = 6.6$

2-B = A + B
2.6 Acres (In B)
Distance = 1220 ft. (E-W)
Slope = 0.0092 ft/ft

$\frac{1220}{5.2 \times 60} = 3.9 + 10 = 13.9$ Min

Tc = 14 Min
$i/2 = 2.2$ $i/10 = 3.6$ $i/25 = 4.6$ $i/100 = 6.3$

2-C = A + B + C
7.0 Acres (In C)
Distance = 2125 ft. (E-W)
Slope = 0.0092 ft/ft

$\frac{2125}{5.2 \times 60} = 6.8 + 10 = 16.8$ Min

Tc = 17 Min
$i/2 = 2.1$ $i/10 = 3.3$ $i/25 = 4.2$ $i/100 = 5.7$

2-D = A + B + C + D
3.3 Acres (In D)
Distance = 2535 ft (E-W)
Slope = 0.0092 ft/ft

$\frac{2535}{5.2 \times 60} = 8.1 + 10 = 18.1$ Min

Tc = 18 Min
$i/2 = 2.0$ $i/10 = 3.1$ $i/25 = 4.1$ $i/100 = 5.6$

2-E = A + B + C + D + E
9.9 Acres (In E)
$Distance_1$ = 3855 ft. (E-W)
$Slope_1$ = 0.0092 ft/ft

$\frac{3855}{5.2 \times 60} = 12.3$

$Distance_2$ = 500 ft (N-S; 70th St.)
$Slope_2$ = 0.0039 ft/ft

$V = 54\ S^{1/2}$
$= 54(0.0039)^{1/2}$
$= 3.4$ fps

$\frac{500}{3.4 \times 60} = 2.4 + 12.3 + 10 = 24.7$ Min

Tc = 25 Min
$i/2 = 1.7$ $i/10 = 2.7$ $i/25 = 3.4$ $i/100 = 4.6$

Time of concentration for drainage area 3 was obtained from area 2 computations.

TIME OF CONCENTRATION
DRAINAGE AREA 4

4-A

21.1 Acres (In A)
Distance = 1230 ft. (E-W)
Slope = 0.0092 ft/ft

$V = 54\ S^{1/2}$
$= 54(0.0092)^{1/2}$

$= 5.2$ fps

$\frac{1230}{5.2 \times 60} = 3.9 + 10 = 13.9$ Min

Tc = 14 Min

$i/2 = 2.2$ $i/10 = 3.6$ $i/25 = 4.6$ $i/100 = 6.3$

4-B = A + B

38.4 Acres
$Distance_1$ = 2580 ft. (E-W)
$Slope_1$ = 0.0092 ft/ft

$\frac{2580}{5.2 \times 60} = 8.3$ Min

$Distance_2$ = 1210 ft. (N-S)
$Slope_2$ = 0.0024 ft/ft

$V = 54\ S^{1/2}$
$= 54(0.0024)^{1/2}$

$= 2.6$ fps

$\frac{1210}{2.6 \times 60} = 7.7 + 8.3 + 10 = 26$ Min

Tc = 26 Min

$i/2 = 1.6$ $i/10 = 2.6$ $i/25 = 3.3$ $i/100 = 4.5$

TIME OF CONCENTRATION
DRAINAGE AREA 5

5-A
16.4 Acres (In A)
Distance = 650 ft. (N-S)
Slope = 0.0002 ft/ft

$V = 54\ S^{1/2}$
$= 54(0.002)^{1/2}$

$\frac{650}{2.4 \times 60} = 4.5$ Min

$= 2.4$ fps

$Distance_2 = 1360$ ft. (E-W)
$Slope_2 = 0.0092$ ft/ft
$V = 54\ (0.0092)^{1/2} = 5.2$ fps
$\frac{1360}{5\text{-}2 \times 60} = 4.3 + 4.5 + 10 = 18.8$ min.

Tc = 19 Min
$i/2 = 1.9$ $i/10 = 3.2$ $i/25 = 4.0$ $i/100 = 5.4$

5-B = A + B
3.3 Acres (In B)
Distance = 2030 ft. (E-W)
Slope = 0.0092 ft/ft

$\frac{2030}{5.2 \times 60} = 6.5 + 10 = 16.5$ Min

Tc = 21 Min
$i/2 = 1.8$ $i/10 = 3.0$ $i/25 = 3.8$ $i/100 = 5.1$

5-C = A + B + C
3.3 Acres (In C)
Distance = 2710 ft. (E-W)
Slope = 0.0092 ft/ft

$\frac{2710}{5.2 \times 60} = 8.7 + 10 + 4.5 = 23.2$ Min

Tc = 23 Min
$i/2 = 1.7$ $i/10 = 2.8$ $i/25 = 3.6$ $i/100 = 4.9$

5-D = A + B + C + D
2.8 Acres
$Distance_1 = 3175$ ft. (E-W)
$Slope_1 = 0.0092$ ft/ft

$\frac{3175}{5.2 \times 60} = 10.2 + 4.5 = 24.7$ Min

Tc = 25 Min
$i/2 = 1.7$ $i/10 = 2.7$ $i/25 = 3.4$ $i/100 = 4.6$

Time of concentration for drainage area 6 was obtained from area 5 computations.

APPENDIX IV:

Runoff Coefficient Calculations
For Drainage Areas 1 Through 6 Located
East Of The Cross Cut Canal.

RUNOFF COEFFICIENT CALCULATIONS

Drainage Area 1
A + B + C + D + E
74.6 Total Acres

52.3 Acres Residential = 0.54 (See Attachment 1)
16.5 Acres Paved Asphaltic = 0.85
5.8 Acres Commercial Roof = 0.95

$$\frac{52.3}{52.3 + 16.5 = 5.8} \times 0.54$$

$$\frac{16.5}{52.3 + 16.5 = 5.8} \times 0.85$$

$$\frac{5.8}{52.3 + 16.5 = 5.8} \times 0.95$$

Runoff Coefficient = 0.64

Drainage Area 2
A + B + C + D + E
28.6 Total Acres

Commercial Area A.D.O.T. Value = 0.85
Runoff Coefficient = 0.85

Drainage Area 3
A + B + C + D
9.3 Total Acres

Commercial Area A.D.O.T. Value = 0.85
Runoff Coefficient = 0.85

Drainage Area 4
A + B
59.5 Total Acres

53.1 Acres Residential = 0.54
5.4 Acres Commercial = 0.85
1.0 Acres Park = 0.25

$$\frac{53.1}{53.1 + 5.4 + 10} \times 0.54$$

$$\frac{5.4}{53.1 + 5.4 + 10} \times 0.85$$

$$\frac{1.0}{53.1 + 5.4 + 10} \times 0.25$$

Runoff Coefficient = 0.56

Drainage Area 5 and 6

A + B + C + D

25.8 Total Acres

25.2 Acres Commericial = 0.85

0.6 Acres Lawn = 0.25

$$\frac{25.2}{25.2 + 0.6} \times 0.85$$

$$\frac{0.6}{25.2 + 0.6} \times 0.25$$

Runoff Coefficient = 0.84

ATTACHMENT 1
RUNOFF COEFFICIENT FOR
RESIDENTIAL AREAS

LOCATION: 68th Street West to Cross Cut Canal, Palm Lane
South of Almeria Alley
TOTAL AREA: 975 ft. x 930 ft. = 906750 ft2

PAVED ROADS: 980 x 35 = 34300 ft2
970 x 35 = 33950 ft2
960 x 35 = 33600 ft2
810 x 35 = 28350 ft2

130200 ft^2 Total Paved Roads

DRIVEWAYS (Average): 30 x 12 = 360 x 84 = 30240 ft^2

ROOF AREA (Average): 55 x 50 = 2750 x 84 = 231000 ft2

ALLEYS: 950 x 15 = 14250 ft^2
940 x 15 = 14100 ft2
930 x 15 = 13950 ft^2
960 x 15 = 14400 ft2

56700 ft^2 Total Alleys

LAWNS: 458610 ft^2 (Based upon an average lot size of 5459.6 ft^2)

PERVIOUS AREAS = ALLEYS + LAWNS = 515310 ft^2
PAVED AREAS = ROADS + DRIVEWAYS = 160440 ft2

RUNOFF COEFFICIENT*: PERVIOUS = 0.25 x 515301 ft2 = 128827
ROOFS = 0.95 x 231000 ft2 = 219450
PAVED = 0.90 x 160440 ft2 = 144396

492673

$$C = \frac{492673}{906750} = 0.54$$

RUNOFF COEFFICIENT = 0.54

*Obtained from A.D.O.T. Values (Figure 3-3).

APPENDIX V:

Existing Storm Drain Capacities.

Existing 36" Pipe

Approximate length = 1,433 feet
Elevation at inlet = 24.50
Elevation at outlet = 19.40
Change in elevation = 5.1 feet
Average slope = 5.1/1433 = 0.0035 ft/ft

$$Q = \frac{1.49A(D/4)^{2/3}S^{1/2}}{n} = \frac{1.49 \times 7.07\ (3/4)^{2/3} \times 0.0035}{0.012}$$
$$= 43 \text{ cfs}$$

Existing 60" Pipe

Approximate length = 1,203 feet
Elevation at inlet = 19.00
Elevation at outlet = 11.12
Change in elevation = 7.9 feet
Average slope = 7.9/1203 = 0.0066 ft/ft

$$Q = \frac{1.49 \times 19.63 \times (5/4)^{2/3}}{0.012} \underline{\times\ 0.0066} = 230 \text{ cfs}$$

Uner 4 feet of pressure head:
Change in elevation = 11.9 feet
Average hydraulic slope = 11.9/1203 = 0.01 ft/ft

$$Q = \frac{1.49 \times 19.63 \times (5/4)^{2/3}}{0.012} \underline{\times\ 0.01} = 283 \text{ cfs}$$

Scottsdale Road System

1203 L.F. 60"
2661 L.F. 72"
2193 L.F. 78"
Elevation at inlet = 1219.00
Elevation at outlet = 1188.68

Flowing full average slope - 30.3/6057 = 0.005 ft/ft

Friction factor $f = \frac{185\ n^2}{d^{1/3}}$

n = 0.012	60" =] f = 0.016	A_1 = 19.63 ft^2
	72" =] f = 0.015	A_2 = 28.26 ft^2
	78" =] f = 0.014	A_3 = 33.17 ft^2

Friction loss $= f \frac{L\ V^2}{2gD}$

Minor Losses

90' Radius = negligible
Turn Structure (72") = 1.0 $v^2/2g$
22-1/2' Radius (78") = 0.25 $v^2/2g$

Outlet Structure (78") = 1.0 $v^2/2g$
22-1/2' Radius (78") = 0.25 $v^2/2g$

Total head loss = 30.3' = (Pipe friction loss) + (Minor losses)

$$h_L = \frac{f.L(Q/A_1)^2}{2gD_1} + \frac{f_2L_2(Q/A_2)^2}{2gD_2} + \frac{f_3L_3(Q/A_3)^2}{2gD_3} + \frac{1.0(Q/A_2)^2}{2g} + \frac{1.5(Q/Q_3)^2}{2g}$$

$$30.3 = 0/06(Q/A_1)^2 + 0.10(Q/A_2)^2 + 0.07(Q/A_3)^2 + 0.016(Q/A_2)^2 + 0.023(Q/A_3)^2$$

$30.3 = 3.914 \times 10^{-4}Q^2$ =] Q = 278 cfs.

Given Pressure head on pipe of 4 feet.

$34.3 = 3.914 \times 10^{-4}Q^2$ =] Q = 296 cfs.

Maximum capacity of system is regulated by 60" pipe which has a capacity of 283 cfs with 4 feet of pressure head.

APPENDIX VI:

Storm Drain System Discharge Calculations
Scottsdale Road To Indian Bend Wash

Storm Drain Peak Discharges (100 year)

Scottsdale Road at Palm Lane:

From Ellis-Murphy Peak Q(Tc=26 min)		= 135 cfs
Less exist. 36" S.D. capacity (Appendix V)		= 43 cfs
	TOTAL	= 92 cfs

Scottsdale at McDowell Road:

From Ellis-Murphy Peak Q(Tc=29 min)		= 87 cfs
From D.A. south of Palm Lane (Tc=30 min)		= 132 cfs
	TOTAL	= 219 cfs

McDowell Road West of 74th Street:

Adj. Q from Scottsdale Road (Tc=32.5 min) 219 x 3.9/4.1		= 208 cfs
Contribution from D.A. 5-A= 68 x 3.7/5.4		= 49 cfs
	TOTAL	= 257 cfs

McDowell East of 74th Street:

Adj from Scottsdale Road (Tc=32.5 min)		= 208 cfs
Contribution from-5-A		= 49 cfs
Contribution from 74th Street		= 18 cfs
	TOTAL	= 275 cfs

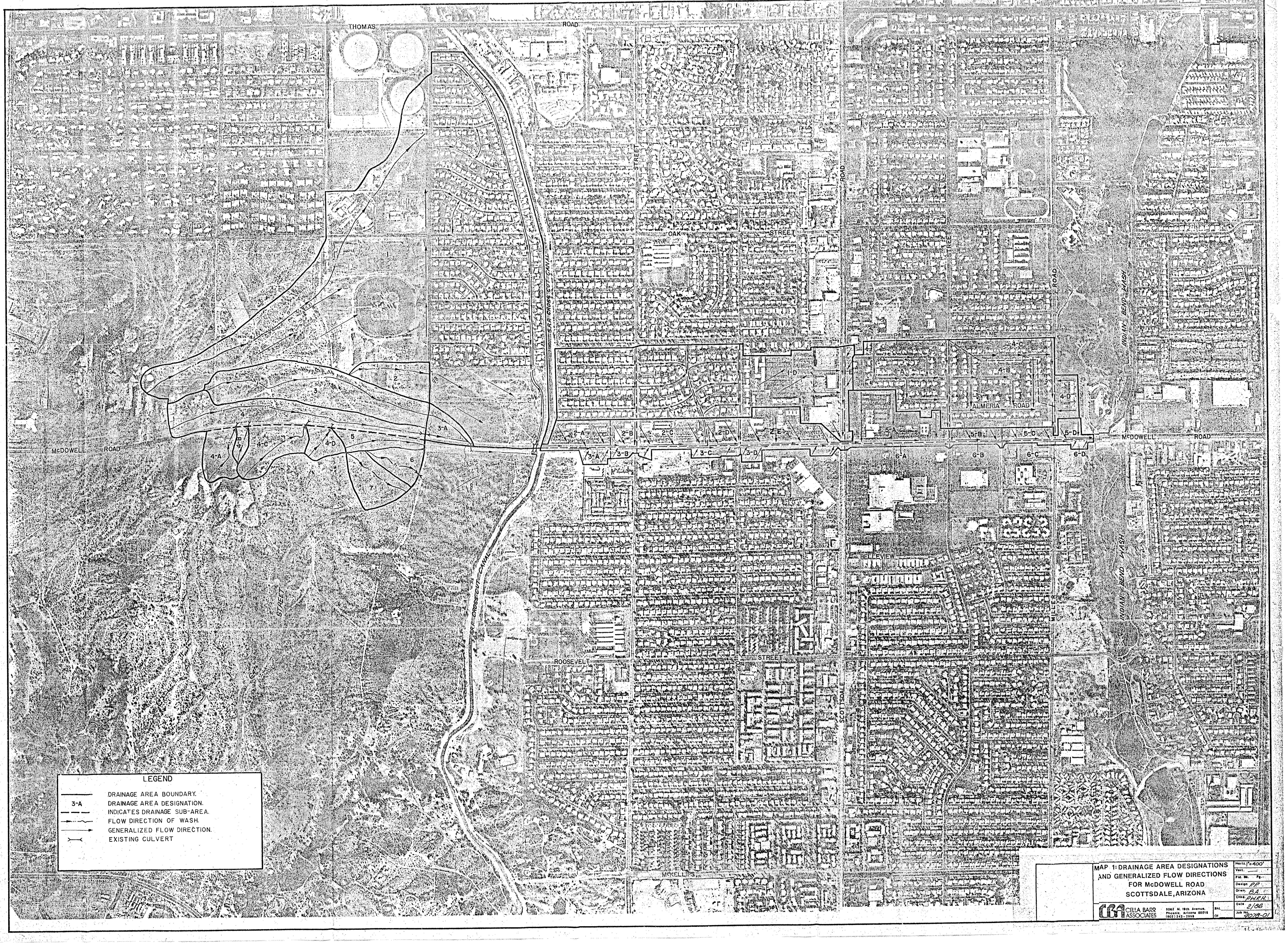
McDowell Road West of Miller Road:

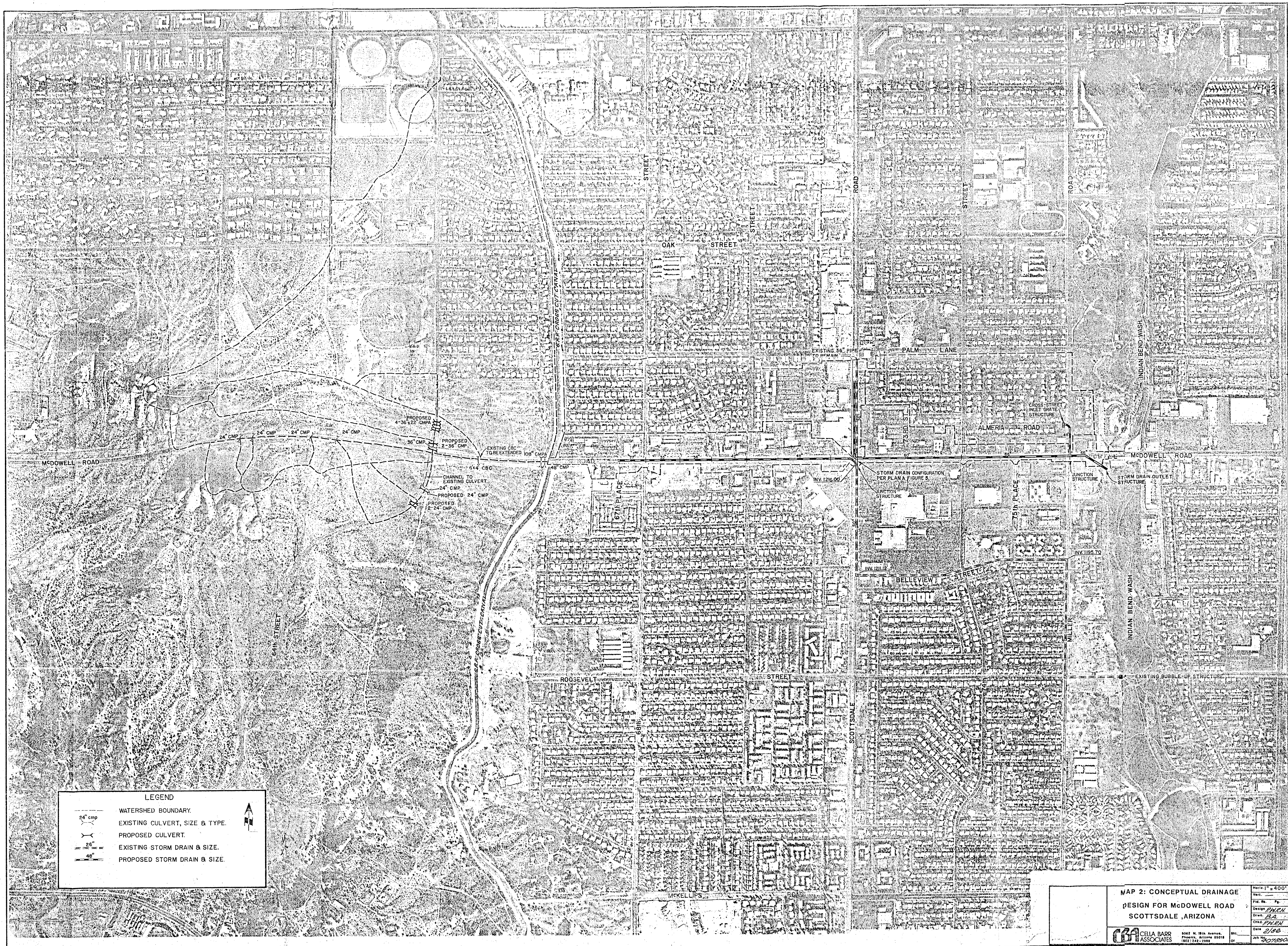
Adj. Q from Scottsdale Road (Tc=35 min) 219 x 3.75/4.1)		= 200 cfs
Contribution from 5-A, 5-B & 5-C = 81x 3.75/4.8		= 63 cfs
Contribution from 74th Street		= 18 cfs
	TOTAL	= 281 cfs

McDowell Road West of Miller Road:

Adj. Q from Scottsdale Road (Tc=35 min)		= 200 cfs
Contribution from 5-A, 5-B, 5-C & 5-D 84 x 3.75/4.6		= 68 cfs
Contribution from 74th Street		= 18 cfs
Contribution from Miller 127 x 3.75/4.6		= 103 cfs
	TOTAL	= 389 cfs

PWRH-85/ej


THOMAS ROAD
OAK STREET
ALMERIA ROAD
McDOWELL ROAD
ROOSEVELT STREET
McKELLIPS
SCOTTSDALE ROAD
INDIAN BEND WASH
1-A
1-B
1-D
2
2-A
2-B
2-C
2-D
2-E
3
3-A
3-B
3-C
3-D
4
4-A
4-B
4-C
4-D
5
5-A
5-B
5-C
5-D
6
6-A
6-B
6-C
6-D
7
LEGEND
DRAINAGE AREA BOUNDARY.
3-A DRAINAGE AREA DESIGNATION.
INDICATES DRAINAGE SUB-AREA.
FLOW DIRECTION OF WASH.
GENERALIZED FLOW DIRECTION.
EXISTING CULVERT
MAP 1: DRAINAGE AREA DESIGNATIONS
AND GENERALIZED FLOW DIRECTIONS
FOR McDOWELL ROAD
SCOTTSDALE, ARIZONA
Horiz. 1"=400'
Vert.
Fld. Bk. Pg.
Design P.P.
Drwn. B.A.
Chkd. P.W.R.H.
Date 2/86
Job No. 4078-01
Sht.
Of
CBA CELLA BARR ASSOCIATES
5062 N. 19th Avenue, Phoenix, Arizona 85015
(602) 242-2999


MAP 2: CONCEPTUAL DRAINAGE
DESIGN FOR McDOWELL ROAD
SCOTTSDALE ,ARIZONA
Horiz. 1" = 400'
Vert. —
Fld. Bk. Pg.
Design P.W.R.H.
Drwn. B.A.
Chkd. P.W.R.H.
Date 2/86
Job No. 4078501
Sht. Of
CBA CELLA BARR ASSOCIATES
5062 N. 19th Avenue, Phoenix, Arizona 85015 (602) 242-2999
LEGEND
WATERSHED BOUNDARY.
24" cmp
EXISTING CULVERT, SIZE & TYPE.
PROPOSED CULVERT.
26"
EXISTING STORM DRAIN & SIZE.
48"
PROPOSED STORM DRAIN & SIZE.
McDOWELL ROAD
OAK STREET
PALM LANE
ALMERIA ROAD
BELLEVIEW STREET
ROOSEVELT STREET
McKELLIPS
SCOTTSDALE ROAD
64th STREET
68th STREET
67th PLACE
75th PLACE
MILLER
INDIAN BEND WASH
PROPOSED 4-36"x22" CMPA
PROPOSED 2-36" CMP
36" CMP
24" CMP
24" CMP
24" CMP
24" CMP
EXISTING CBC TO BE EXTENDED
108" CMPA
6x4 CBC
CHANNEL TO EXISTING CULVERT
24" CMP
PROPOSED 24" CMP
PROPOSED 2-24" CMP
EXISTING 36" PIPE TO REMAIN
STORM DRAIN CONFIGURATION PER PLAN & FIGURE 5
JUNCTION STRUCTURE
CROSS STREET INLET GRATE STRUCTURE
JUNCTION STRUCTURE
STORM DRAIN OUTLET STRUCTURE
EXISTING BUBBLE-UP STRUCTURE
INV 1195.70
INV 1211.12